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Map of the Upper Cow Creek Watershed Survey Area

This document is a specialist report. It is meant to assist managers in understanding current conditions of a stream corridor and possibly how those conditions have developed over a period of time. Recommendations are drawn up emphasizing the aquatic resource, although the accomplishment of multiple use is considered within those recommendations.

Readers should note that there is some amount of repetition in this document. The author assumes that readers may only read certain sections; therefore, points or observations may be repeated.

INTRODUCTION
Cow Creek 2001 Stream Survey

The Santa Fe National Forest conducted stream surveys in the upper Cow Creek Watershed during the summer and fall of 2001. The streams included in the survey were Cow Creek, Elk Creek (tributary to Cow), and Sheep Creek (tributary to Elk). A total of 23.90 miles of stream were surveyed: 18.4 in Cow Creek, 4.0 in Elk Creek, and 1.5 in Sheep Creek. The results of the Elk and Sheep Creek stream surveys can be found in their respective stream inventory reports.

Cow Creek is a 4th order stream within the Santa Fe National Forest boundary. Cow Creek flows for approximately 30 miles before joining the Pecos River one mile north of Sands, New Mexico. Elk and Soldier Creeks form the headwaters of Cow Creek, with Bull, Osha, and Manzanares Creeks constituting the major tributaries. The state has classified several designated uses within the Cow Creek Watershed, including domestic water, high quality cold-water fisheries, irrigation, livestock watering, wildlife habitat, and secondary contact recreation (secondary contact is defined as body contact with water; some examples are rafting, canoeing and kayaking; NMED 2002). Cow Creek and its tributaries generally flow in a southerly direction. Cow Creek was surveyed from a starting location on private property just below the forest boundary (T16N, R13E Sec 29 NE¼, 7280' elevation) to its headwaters (T18N, R13E, Sec. 27 NW¼, 10800' elevation).

The Cow Creek stream survey was performed by two-person seasonal fisheries crews from the Pecos/Las Vegas Ranger District, Santa Fe National Forest, in the summer of 2001. Mid-way through the Cow Creek survey the crew changed when the original crew's employment ended. The original crew surveyed Reaches 2-7. The second crew picked up where the first left off and completed the survey, finishing Reaches 8-11. Reach 1 was not surveyed since it is outside the Forest Boundary.

The entire wetted length of Cow Creek was surveyed within Forest Service managed land. In addition, permission was obtained to survey several sections on private property. Inventories were performed using the Region 3 Stream Inventory Handbook Level I and II, Version 1.0 (USFS 2001), adapted from Hankin and Reeves' survey methodology. Cow Creek was divided into reaches based on geomorphology and change in flow and given a stream classification (Rosgen 1998), then into individual habitat units of riffles, pools, barriers (chutes and waterfalls), culverts, side channels, and tributaries. Each individual habitat unit was assigned a Natural Sequence Order (NSO), starting with 1 and continuing upstream sequentially to Cow Creek's headwaters. Table 1 lists the direct measurements and estimations that were made on each NSO:

Table 1. Measurements and estimations recorded.

Measurements	Estimations
Maximum depth of pools, side channels, and tributaries	Average depth of riffles (based on continuous measurements throughout survey)
Depth of pool tail crests	Substrate composition
Bankfull width, depth, and stream discharge	Bank instability (in total feet per NSO)
Number of Large Woody Debris (LWD) within bankfull	Average widths of riffles, pools, side channels, and tributaries
Water Temperature (every 10th NSO)	Length of tributaries and side channels
Water Temperature of tributaries	Slope and contribution to overall stream flow

Total stream length was calculated by totaling the lengths of riffle, pool, culverts, and barrier NSO's. *Total stream habitat* was calculated using all side channel lengths as well as riffle, pool, culvert and barrier lengths.

In addition, the locations of features of interest were recorded using a Trimble GeoExplorer 3 (see Photo 1), and then placed into a GIS layer. Features of interest included:

- ✓ Culverts
- ✓ Log Jams
- ✓ Mouths of Tributaries
- ✓ Reach Breaks
- ✓ Stream Discharge Stations
- ✓ Waterfalls and Chutes

Photo 1. Reach 9, NSO168, T17. Stream survey crew obtaining the UTM coordinates for a tributary to Cow Creek with a Trimble GeoExplorer 3 GPS unit (21 Aug 2001).

The main objectives of this survey were to: (1) collect baseline data to determine the quality of habitat and floodplain condition of Cow Creek after the Viveash Fire of 2000,

(2) locate existing barriers and identify areas for possible construction of barriers to upstream migration of non-native salmonids, (3) identify possible restoration needs, and (4) identify fish species presence and distribution.

A matrix of factors and indicators was developed to tie to stream habitat information collected during this survey (see Table 2). The matrix originally was developed in Region 6 (Washington and Oregon), but was modified for mountain streams in the intermountain west and relates to regulations determined by New Mexico Environment Department (NMED). The matrix was further refined to incorporate geology of streams historically occupied by RGCT. While not all inclusive, this table does give general guidelines as to the characteristics of a properly functioning stream for Rio Grande cutthroat trout and its native fish assemblage.

Table 2. Matrix of Factors and Indicators of Stream Health Condition for Historic and Occupied Rio Grande Cutthroat Trout Streams as Related to R3 Stream Habitat Inventory.

FACTORS	INDICATORS	Properly Functioning	At Risk	Not Properly Functioning
Water Quality	***Temperature – State of New Mexico Standards***	<20°C (68°F) (3 day avg. max)	≥20°C (68°F) <23°C (73.4°F) (3 day avg. max)	≥23°C (73.4°F) (3 day avg. max)
	Temperature – Salmonid Development	≤17.8°C (64°F) (7 day avg. max)	>17.8º (64ºF) < 21.1º (70ºF) (7 day avg. max)	≥21.1ºC (70ºF) (7 day avg. max)
Habitat Characteristics	**Sediment**	<20% fines (sand, silt, clay) in riffle habitat. Fine sediment within range of expected natural streambed conditions		≥20% fines (sand, silt, clay) in riffle habitat. Fine sediment outside of expected natural streambed conditions.
	Large Woody Debris[1]	>30 pieces per mile, >12" diameter, >35 feet in length	20-30 pieces per mile, >12" diameter, >35 feet in length	<20 pieces per mile, >12" diameter, >35 feet in length
	Pool Development[2]	≥30% pool habitat by area		<30% pool habitat by area
	Pool Quality	Average residual pool depth ≥1 foot		Average residual pool depth <1 foot
Channel Condition and Dynamics	**Width Depth Ratios by Channel Type** *(utilize Rosgen type and range given if applicable)*	Width/depth ratios and channel types within natural ranges and site potential		Width/depth ratios and channel types are well outside of historic ranges and/or site potential
		Expected range of bankfull width/depth ratios and channel type	***Rosgen Type*** A, E, G B, C, F D	***W/D Ratio*** <12 12-30 >40
	Streambank Condition[3]	<10% unstable banks (lineal streambank distance)	10-20% unstable banks (lineal streambank distance)	>20% unstable banks (lineal streambank distance)

[1] Large Woody Debris numeric are not applicable in meadow reaches
[2] Pool Development numeric are applicable to 3rd order or larger streams
[3] Streambank Condition numeric are not applicable in reaches with > 4% gradient

BASIN SUMMARY

Table 3. Stream summary table for Cow Creek

SURVEYORS:	Cody Robertson and Anne Bolick (Reaches 2-7), Chris Luerkens and Dwayne Lefthand (Reaches 8-11), Chris Gatton (Pecos Team Leader)
SURVEY DISTANCE:	18.4 miles (97,255 feet)
LOCATION:	
County:	San Miguel
Forest:	Santa Fe National Forest
District:	Pecos / Las Vegas Ranger District
Drainage:	Cow Creek
Tributary to:	Pecos River
Mouth Location:	T14N R13E Section 24
WATERSHED:	
HUC Code:	1306000102
Watershed Area:	152,342 acres
Stream Order:	4
Stream Length:	30.33 miles
AQUATIC BIOTA:	
Fish Species:	Rio Grande cutthroat trout, longnose dace and brown trout observed; rainbow trout documented historically (stocked)
Amphibian Species:	None observed

EXECUTIVE SUMMARY

Cow Creek is a 4th order stream originating approximately five miles east of Terrero, draining over 152,000 acres located south of Elk Mountain. Cow Creek flows in a southerly direction over 30 miles to where it joins the Pecos River one mile north of Sands, NM. Tributaries of Cow Creek include Bull Creek, Elk Creek, and Manzanares Creek. Although Cow Creek is a primary trout stream of the Upper Pecos Drainage, both road access and the large amount of private land along the stream limit public use.

Cow Creek has historically contained rainbow, brown, and Rio Grande cutthroat trout (RGCT), although RGCT were the only native trout species. Longnose dace were also present in Cow Creek historically, and are also native to the drainage. Since the Viveash fire in 2000, however, fish distribution has been severely limited. In June 2000 immediately following the Viveash Fire, Forest Service and New Mexico Game and Fish (NMGF) personnel removed 80-100 Rio Grande cutthroat trout from Cow Creek and transported them to the Mora National Fish Hatchery and Technology Center in Mora, NM. Stream surveys in 2001 failed to locate any fish in Cow Creek.

Cow Creek was broken into 11 reaches during the 2001 stream survey, based on stream and valley morphology, dramatic changes in stream flow, and boundaries with private property that prevented access. The survey began on private property just below the boundary of Forest Service land, and continued upstream to Cow Creek's spring-fed headwaters. Reaches were numbered sequentially from the survey's start to the finish. Inaccessible private areas not surveyed were assigned a reach number as well.

The stream gradient of surveyed reaches on Cow Creek varied from 0.9% in the middle (Reach 5) to 6.2% near the headwaters (Reach 10). Cow Creek has a general increase in slope moving upstream typical of high mountain streams, with the highest gradient being found in the upper reaches near the headwaters.

Table 4. Description and length of stream reaches on Cow Creek.

Reach	River Miles	Landmarks	Land Owner
1*	0 - 11.0	Mouth to Private Boundary (T16N, R13E, Sec. 29)	Private
2	11.0 – 13.45	Private Boundary (T16N, R13E, Sec. 29) to Manzanares Creek	Private, SFNF
3	13.45 – 14.23	Manzanares Creek to Valdez Bridge	Private
4	14.23 – 15.04	Valdez Bridge to Road 86 Crossing	Private
5	15.04 – 17.26	Road 86 Crossing to Private Boundary (Secs. 36/1)	Private
6*	17.26 – 18.16	Private Boundary (Secs. 36/1) to Cow Creek Campground	Private
7	18.16 – 19.94	Cow Creek Campground to Martin Ranch Bridge	SFNF, Private
8	19.94 – 22.96	Martin Ranch Bridge to Martin Ranch / SFNF Boundary	Private
9	22.96 – 25.11	Martin Ranch / SFNF Boundary to Elk Creek	SFNF, Private
10	25.11 – 26.33	Elk Creek to Small Unnamed Tributary	SFNF
11	26.33 – 30.33	Small Tributary to Headwaters	SFNF

* - Reaches 1 and 6 were not sampled due to the lack of access to private property; lengths of these reaches were estimated to the nearest tenth of a mile.

Generally, Cow Creek largely lacks large woody debris and pool habitat. Large woody debris is a critical pool-forming component. In addition, high sediment loading in the watershed was apparent and is another culprit for the lack of pools. High sediment loads are likely attributable to the combined effects from the Viveash Fire of 2000, high road density (closed and open) and private land management. As the watershed recovers, it is likely there will be a substantial recruitment of large woody debris, which will help in pool formation and sorting fines.

Cow Creek has become a very flashy stream system since the Viveash Fire in 2000 (see Photo 2). The dramatic effects of the fire on the flow regime of Cow Creek will be felt for years to come. During the summer of 2001 Cow Creek often flowed out of its banks into the floodplain. Fire impacts to the soils of the Cow Creek Watershed include reduced aggregate stability, reduced permeability, increased runoff and erosion, and reduced organic matter. These impacts have created a system prone to intense flood events.

Photo 2. Flash flood in Cow Creek following the Viveash Fire (19 July 2000).

Habitat Characteristics

Table 5 below shows the overall functioning of Cow Creek as related to the matrix of factors and indicators of stream health condition for historic and occupied Rio Grande cutthroat trout streams.

Table 5. Stream Conditions on Cow Creek.

Factors	Indicators

habitat length, as they are not on the main stem of the stream. Side channels are not used to determine stream length.

Cow Creek is composed of 93% riffle habitat, with only 3.5% of the habitat in pools. Although the pool to riffle ratio is 1:1.2, pools are small in size, with large riffles separating them. Cow Creek has several riffles greater than 1000 feet in length, with the longest measuring 11,717 feet (2.2 miles). Two of the nine reaches surveyed (Reaches 4 and 5) lacked pools entirely. Although this fact may be related to surveyor error, it still emphasizes the limited pool formation in Cow Creek. Using the above matrix for stream health, ≥30% of stream habitat should be pool habitat for a properly functioning stream for Rio Grande cutthroat trout. With only 3.5% habitat in pools, Cow Creek is **not properly functioning** for pool development.

The lack of pool habitat on Cow Creek can be largely attributed to the effects of the Viveash Fire. Erosion from intense runoff events has greatly reduced pool volume and quantity in Cow Creek, filling in pools with sediment and silt. More detail on the Viveash Fire and its effects, including a map of fire severity and subwatershed boundaries, is given in the Fire Section.

Table 6. Overall stream survey summary for Cow Creek.

COW CREEK **Stream Length Surveyed:** 97,255 (18.4 miles)					
Habitat Type	**Total Number**	**Total Feet**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	168	3554	3.7	3.5	≥30% Stream Habitat
Riffle	194	93498	96.1	93.2	-
Falls / Chutes	13	173	0.2	0.2	-
Side Channel	22	3040	-	3.0	-
Tributary	54	-	-	-	-
Culvert	1	30	0.03	0.03	-
Total	452	100295	100.0	100.0	-

Lacking baseline data preceding the fire makes it unclear how much of the stream's current condition is a result of fire effects alone. Other factors such as private land use, historic land management and the lack of large woody debris have most likely contributed to the condition of Cow Creek as well.

Due to the post-fire flashy condition of Cow Creek, the stream has changed its course in places to accommodate the increased volumes of water in the channel after rain events (see Photo 3). In addition, it has formed new side channels and braids. Particularly on private land where less standing trees were present, the stream at times was braided into several channels flowing through the grassy floodplain.

Photo 3. Reach 8, NSO133, R55. Typical braided riffle in Cow Creek after a light rain event (14 Aug 2001).

The dominance of riffle habitat in Cow Creek is of some concern. Until the upper Cow Creek Watershed heals and returns to its natural equilibrium, the amount of riffle habitat in Cow Creek will remain high as sediment input and flashy events continue. Peak flows from frontal storms or high moisture monsoon conditions could continue to produce significant flood peaks for the next 3-5 years as revegetation occurs within the watershed (USFS 2000). Cow Creek will continue to experience a significant increase in annual water yield for many years, with higher peaks in spring flows. These high flows should be simply "out of bank" conditions, and not as damaging compared to storm events (USFS 2000).

Table 7. Habitat summary and substrate percentages for riffle habitat in Cow Creek.

Riffle Habitat Summary						
	# Riffles	**Avg Length (feet)**	**Avg Width (feet)**	**Avg Depth (feet)**	**Avg Max Depth (feet)**	
Cow Creek	197	481.9	11.8	0.8	1.8	
Riffle Substrate Summary						
	% Sand	**% Gravel**	**% Cobble**	**% Boulder**	**% Bedrock**	**Total**
Cow Creek	27.8	26.0	27.3	14.4	4.5	100.0
Properly Functioning Indicators	<20	-	-	-	-	-

Orange = dominant substrate type
Red = not properly functioning

In general, the average length of riffles decreased moving upstream with the greatest lengths being in the middle reaches (Reaches 4, 5, and 7). Riffle average widths and depths decreased moving upstream as well, as would be expected as discharge decreases.

The main channel through Reaches 4 and 5 is composed entirely of riffle habitat with essentially 3 miles (15,945 feet) of uninterrupted riffle. In the upper reaches of the stream (reaches 8-11), riffle lengths are shorter with more pools interspersed throughout. This is primarily due to changes in geomorphology and land use found in private land, and the fact that reaches 10 and 11 were largely untouched by the Viveash Fire.

Table 8. Habitat summary and substrate percentages for pool habitat in Cow Creek.

Pool Habitat Summary											
Reach	# Of Pools	Avg. Length	Avg. Width	Avg. Max Depth	Avg. PTC	Avg. Residual Depth	Pools/Mile	# of Pools w/ Residual Depth >1'	Pools w/ Residual Depth >1'/Mile	# of Pools w/ Max. Depth >3'	Pools w/ Max. Depth >3'/Mile
Entire River	168	27.2	13.3	2.5	0.7	1.8	9.1	108	5.9	20	1.1
Properly Functioning Indicators	-	-	-	-	-	>1'	-	-	-	-	-

Substrate Summary							
Reach	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock	Total
Entire River	41.3	23.5	18.7	8.2	8.3	100.0

Cow Creek is **not properly functioning** in terms of the average stream sediment in riffles, having greater than 20% fines in riffle habitat (see Table 7). Sand was the overall dominant substrate type in riffle habitat areas (27.8%), though it was followed closely by cobble and boulder (27.3% and 26.0%, respectively). The amount of fine substrate is likely due to sediment input from the Viveash Fire. During and after storm events, Cow Creek at times was turbid enough to prevent surveying as the substrate was entirely obscured.

Figure 1. Cross-sectional view of a stream pool. The red line indicates where the max depth and depth at pool tail crest are measured, with the yellow line being the resulting residual depth level (image modified from Krisweb 2001 by author).

Cow Creek is **properly functioning** for pool quality. Pool quality refers to the average residual depth in pools being greater than or equal to one foot (see Figure 1 for further explanation). The average residual depth pool depth in Cow Creek was 1.8 feet, which is above properly functioning. Although pools in Cow Creek have adequate residual depths, they are few and far between. 60 out of 168 pools were below standard residual

depth but most of these are in Reaches 10 and 11, which has smaller pools by nature of the size of stream. As stated above, pool habitat comprises only 3.6% of the stream habitat in Cow Creek.

Table 9. Habitat characteristics for Cow Creek.

	Pool:Riffle Ratio	Avg Bankfull Width:Depth	Pieces of Large Woody Debris per Mile	Total Feet of Unstable Banks	% Unstable Banks
Cow Creek	1:1.2	15:1	5.1	8195	4.0[1]
Properly Functioning Indicators	-	-	>30	-	<10

Rreaches 3, 7, 10, and 11 have gradients greater than 4% and therefore are not analyzed for bank stability criteria.

The average bankdfull width:depth ratio of 15:1 for all of Cow Creek is fairly in balance with the Rosgen stream types for the area. Individual reach width:depth ratios are listed in the reach by reach comparison section that follows.

Cow Creek has extremely low amounts of large woody debris (LWD). With 5.1 pieces per mile, the stream is clearly **not properly functioning** for LWD. A properly functioning stream rating requires greater than 30 pieces of LWD per mile. The lack of woody debris in Cow Creek can be largely attributed to past land use practices. The average number of LWD per mile for reaches 2-5 and 7-8 was 2.4 pieces per mile (reaches 1 and 6 were not surveyed), whereas the average for Reaches 9-11 was significantly higher at 9.1 pieces per mile. In addition to past land use, the dramatic flood flows of the past two years have also been detrimental to LWD abundance in the Cow Creek system. The intense flood conditions since the Viveash fire have effectively blown out all but the most stable LWD in the stream channel. Past fire suppression has also contributed to the reduction of LWD recruitment in Cow Creek by limiting the range of natural fires and thus reducing disturbance that could contribute to LWD recruitment.

In years to come, the large amount of disturbance due to fire high in the Cow Creek Watershed should act to replenish some of the LWD as snags in the burned areas begin to fall and find their way into the stream and floodplain in the high gradient reaches near the headwaters of Cow Creek. These high gradient forested reaches, called transport reaches, serve to deliver LWD to the remainder of the system. Once in the stream or floodplain in the upper reaches, wood will be transported downstream until the gradient decreases, where it settles out or is trapped by landform features. These lower gradient reaches that ‘catch’ debris from upstream are termed response reaches.

Photo 4. Reach 9, NSO212, F8. Waterfall over a log creating a plunge pool on Cow Creek. Note the fire-damaged trees falling in towards the stream (22 Aug 2001).

Despite the amount of erosion and flood damage in the Cow Creek Watershed following the Viveash Fire, Cow Creek's streambanks remain largely intact. With only 4% of streambanks found to be unstable, Cow Creek is **properly functioning** in terms of bank stability. Reaches 3, 7, 10, and 11 were excluded from the bank stability numeric due to gradients exceeding 4%. Reach 4 had bank instabilities exceeding 20% (23.4%) and was found to be not properly functioning, while all other reaches were below the 10% standard. The high percentage of unstable banks within Reach 4 is due to past and current private land use practices, and does not reflect the influence of the Viveash Fire. Reach 4 consists only of riffle habitat, flowing through a heavily used area by livestock and people. Banks consisted largely of mud with spotty vegetation. Old road crossings were evident within the reach.

Reach by Reach Comparison

Cow Creek was broken into 11 separate reaches. Reaches 1 and 6 consisted of private land that was not surveyed due to a lack of access. Table 10 below summarizes the habitat characteristics for each reach and for the entire stream.

Table 10. Reach by reach summary of habitat characteristics for Cow Creek.

Reach	Total Length (miles)	% Gradient	Rosgen Channel Type	% Pool Habitat	% Riffle Habitat	% Side Channel Habitat	Dominant Substrate in Riffles	Dominant Substrate in Pools	LWD per Mile	Bankfull W:D Ratio	% Unstable Banks
1	11.0	1.8	Private	Land	Not	Surveyed	-	-	-	-	-
2	2.45	3.4	B3	3.3	95.0	1.5	Cobble	Sand	1.6	16 : 1	1.1
3	0.78	4.9	A1	5.6	90.6	1.4	Bedrock	Bedrock	5.1	13 : 1	8.6 [2]
4	0.81	1.4	C5	0	99.1	0.9	Sa/Gr/Co	N/A	0	17 : 1	23.8
5	2.22	0.9	C5	0	94.7	5.1	Sa/Gr/Co	N/A	2.6	15 : 1	0
6	0.90	1.7	Private	Land	Not	Surveyed	-	-	-	-	-
7	1.78	4.2	A4	3.0	95.0	2.0	Gravel	Sa/Gr	3.9	16 : 1	14.4 [2]
8	3.02	1.8	C5	4.8	89.2	6	Sand	Sand	2.0	13 : 1	4.1
9	2.15	3.5	B4	6.0	87.6	6.4	Gravel	Sand	9.3	15 : 1	4.0
10	1.22	6.2	A4	4.4 [1]	92.8	1.1	Gravel	Gravel	12.3	13 : 1	0.7 [2]
11	4.00	5.7	A4	3.5 [1]	96.3	0.2	Gravel	Sand	15.5	12 : 1	0.9 [2]
Entire Stream	30.33	2.9	-	3.6	93.1	3.3	Sand	Sand	5.1	-	4.0
Properly Functioning Indicators	-	-	-	≥30	-	-	-	-	>30	A,E,G <12 B,C,F 12-30 D >40	<10

[1] In reaches 10 and 11, Cow Creek is a 2nd order stream and is not applicable to pool development criteria.
[2] Reaches 3, 7, 10, and 11 have gradients greater than 4%, thus not applicable to bank stability criteria.

The Rosgen channel types in Cow Creek were largely in balance with the land form. Width-to-depth ratios were slightly high compared to stream gradient in Reaches 3, 7, and 10. Each of these reaches had a gradient greater than 4%, placing them in Rosgen's type A channel category. Ideally, type "A" channels should have width:depth ratios less than 12. With the absence of channel type data predating the Viveash Fire, it is uncertain whether the widening of the stream channel in these areas is due to the fire alone, but erosion due to fire disturbance is certainly resulting in a wider, shallower stream.

As discussed above, pool habitat is extremely low in Cow Creek. Reaches 4 and 5, through private land, had no pools present throughout their combined length of 3.03 miles. The greatest percentage of pool habitat occurred in Reach 9, with a mere 6% habitat in pools. With ≥30% required for a properly functioning rating, Cow Creek is far below desirable conditions.

Large woody debris is another area of concern in Cow Creek. LWD is highest in the upper forested reaches of Cow Creek. As trees damaged in the Viveash fire begin to make their way into the stream channel in these reaches, wood will be transported downstream to settle out in areas of lower gradient. In the near future, LWD numbers throughout the Cow Creek system should increase substantially due to the large, intense disturbance generated by the Viveash Fire.

Tributaries

According to USGS 1:24000 quadrangle maps, there are 42 perennial tributaries to Cow Creek within the sampled area. Of these, five are named: Rito Manzanares, Rito Chaparito, Rito de la Osha, Soldier Creek, and Elk Creek. 54 tributaries were identified and recorded during the 2001 stream inventory; however, they didn't always correspond to tributaries identified on the USGS maps. In many cases, tributaries noted on the map were not visible in the field. Tributaries identified in the field consisted of streams, springs, and seeps.

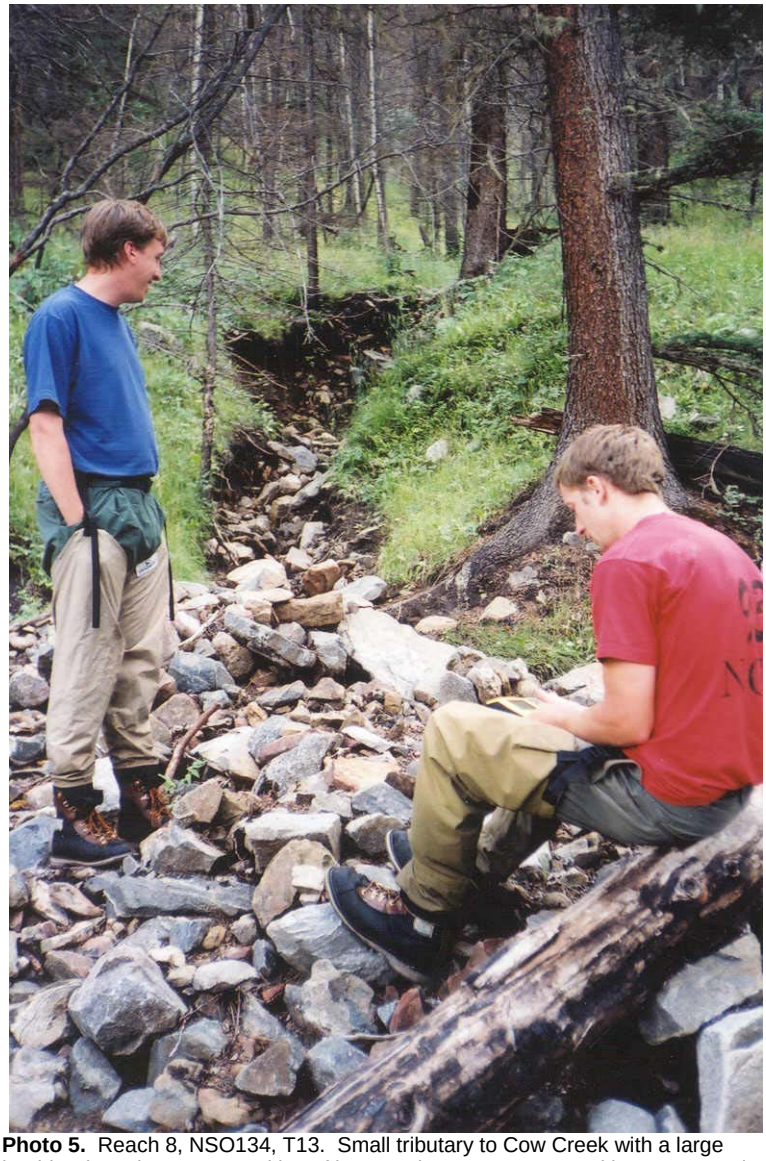


Photo 5. Reach 8, NSO134, T13. Small tributary to Cow Creek with a large boulder deposit. Vast quantities of large rocks were transported by summer rain events and deposited in fans such as this one (14 Aug 2001).

Table 11. Tributary summary for Cow Creek.

Reach	Habitat Number	Mouth Location Facing Upstream	Type	Name	% Flow	Date (2001)	Time	Trib Temp (F)	Stream Temp (F)	Comments
2	T1	RB	Spring		2	06 Jul	1700	50	67	Passes through root swell; cool, clear spring
2	T2	RB	Stream		5	06 Jul	1334	52	65	Braided tributary
2	T3	RB	Stream	Rito Manzanares	40	06 Jul	1354	60	65	Contributes large amount of flow to Cow
5	T4	RB	Stream		2	12 Jul	1237	80	67	Very sandy, old culvert in tributary but water flows around it
5	T5	RB	Stream		5	13 Jul	0955	64	65	Muddy streambed
5	T6	RB	Stream		5	13 Jul	1025	60	65	Clear water with gravel bed
5	T7	RB	Stream		5	13 Jul	1355	64	66	Culvert upstream that forms pool 2' deep
5	T8	RB	Stream		3	13 Jul	1415	60	66	Very small muddy trickle
7	T9	LB	Stream	Rito Chaparito	10	17 Jul	1115	58	56	Very muddy
8	T10	RB	Stream	Rito de la Osha	10	18 Jul	-	-	-	Crew missing thermometer
8	T11	RB	Stream		5	13 Aug	1540	58	56	
8	T12	LB	Stream	Soldier Creek	5	13 Aug	1230	59	54	
8	T13	RB	Stream		2	13 Aug	1340	55	55	Huge deposition fan of materials (photo on pg 16)
8	T14	RB	Seep		1	21 Aug	1115	54	55	Silty, seeps out from side valley
8	T15	LB	Stream		2	21 Aug	1148	63	55	
9	T16	RB	Seep		1	21 Aug	1340	52	56	Seeps out 20 feet from stream
9	T17	RB	Stream		2	21 Aug	1505	57	57	
9	T18	RB	Stream		1	21 Aug	1505	57	57	Flows into T17, high gradient
9	T19	LB	Stream		3	21 Aug	1530	52	57	
9	T20	RB	Seep		1	21 Aug	1600	54	57	
9	T21	RB	Seep		4	22 Aug	1000	49	50	Seeps out of side canyon in 3 different spots
9	T22	RB	Stream		8	22 Aug	1045	48	50	Large debris deposit at mouth
9	T23	LB	Stream		6	22 Aug	1200	58	53	Flows into side channel S18
9	T24	LB	Stream		3	22 Aug	1340	61	55	

Table 12 is continued on the following page.

Table 12. (continued)

Reach	Habitat Number	Mouth Location	Type	Name	% Flow	Date (2001)	Time	Trib Temp (F)	Stream Temp (F)	Comments
9	T25	RB	Stream		8	22 Aug	1450	56	57	Trib is forked, flows into Cow in 2 places
9	T26	RB	Stream		5	23 Aug	1100	53	51	Cascading stream
9	T27	RB	Stream	Elk Creek	60	23 Aug	1330	54	54	Thermograph located just above Elk Creek
10	T28	LB	Stream		15	28 Aug	1200	49	50	Meadow, deeply entrenched
10	T29	RB	Stream		15	28 Aug	1245	46	50	
10	T30	RB	Stream		5	28 Aug	1500	56	53	Very high gradient
10	T31	RB	Stream		5	28 Aug	1200	52	50	
11	T32	RB	Stream		5	28 Aug	1445	56	54	
11	T33	RB	Stream		5	28 Aug	1517	58	54	No visible surface entrance to stream
11	T34	RB	Stream		8	30 Aug	1145	45	48	
11	T35	RB	Stream		8	30 Aug	1400	47	51	Braided, enters cow in several locations
11	T36	RB	Stream		5	04 Sep	-	-	-	Crew missing thermometer for next few tributaries
11	T37	RB	Stream		8	04 Sep	-	-	-	Tree growing in trib channel, flows around it
11	T38	LB	Stream		5	04 Sep	-	-	-	
11	T39	LB	Stream		3	04 Sep	-	-	-	
11	T40	LB	Stream		3	04 Sep	-	-	-	
11	T41	RB	Stream		2	04 Sep	-	-	-	
11	T42	LB	Spring		2	05 Sep	1000	41	44	Spring emerges from under a tree, tons of seepage in the area
11	T43	RB	Seep		2	05 Sep	1230	46	46	
11	T44	LB	Seep		1	05 Sep	1300	46	46	
11	T45	LB	Spring		8	05 Sep	1515	43	47	
11	T46	RB	Seep		3	06 Sep	1030	43	43	Seep along right bank
11	T47	LB	Spring		7	06 Sep	1125	48	45	
11	T48	LB	Stream		2	06 Sep	1320	55	45	
11	T49	RB	Seep		1	06 Sep	1330	48	45	
11	T50	LB	Stream		3	06 Sep	1345	49	45	Stream and seep area on left bank
11	T51	RB	Stream		3	06 Sep	1400	49	45	
11	T52	LB	Stream		2	06 Sep	1445	52	45	Channel not well defined
11	T53	RB	Stream		20	06 Sep	1510	48	45	No GPS coverage
11	T54	RB	Seep		8	10 Sep	1135	39	38	Wide seep area

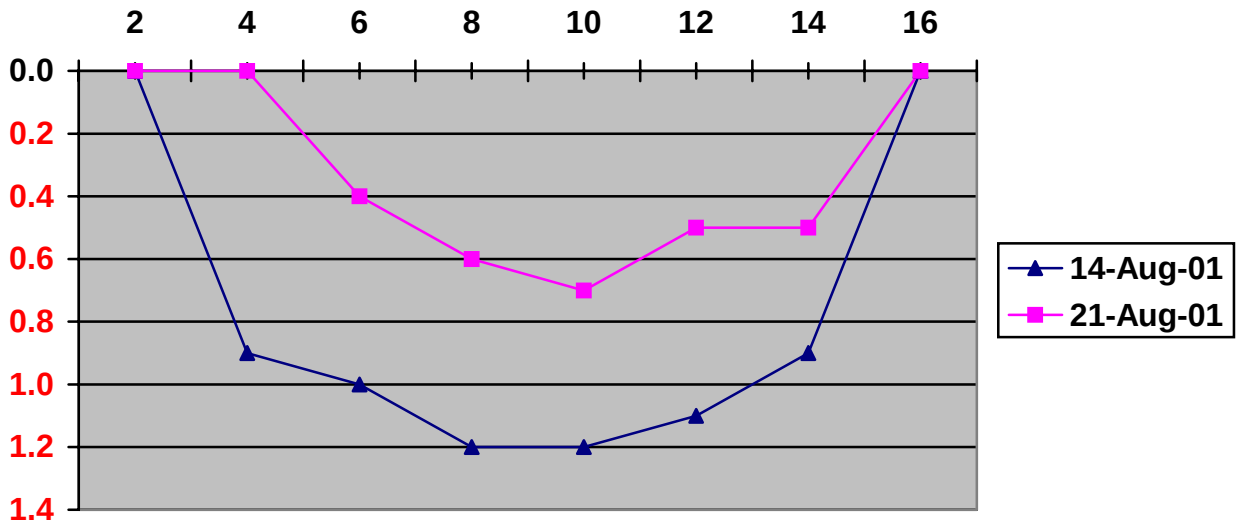
In 2001, several riparian assessments were conducted on tributaries of Cow Creek utilizing the following protocol: "A User Guide to Assess Proper Functioning Condition (PFC) and Supporting Science for Lotic Areas (BLM 1998)." PFC surveys were done on Sheep Creek, Elk Creek, Soldier Creek, and the Rito Chaperito (USFS Watershed Files).

- Sheep Creek – **Nonfunctional** due to the extreme flash flows that occur as a result of the lack of vegetation on the upland watershed. Large amounts of sediment are being transported into Elk Creek and Cow Creek as Sheep Creek continues to incise. Riparian vegetation is not plentiful enough to hold banks in place.
- Elk Creek – **Functional–At Risk with an upward trend** due to extreme flash flows. Streambanks are currently vegetated by grass species from rehabilitation efforts following the Viveash Fire. These species are not and will not hold up to the increased flows. Large amounts of sediment are being transported into Cow Creek as upper Elk Creek continues to incise and widen. However, given time the riparian species present should become more plentiful and help the system reach equilibrium.
- Upper Soldier Creek – **Proper Functioning Condition**.
- Lower Soldier Creek – **Functional-At Risk with a downward trend** due to the lack of stability, the high possibility of continued flash flows, and continued destabilization of the riparian area.
- Upper Rito Chaperito – **Functional-At Risk with an upward trend** due to the high flows impacting streamside vegetation. Sediment is being transported into Cow Creek as the Chaperito continues to try to equilibrate.
- Lower Rito Chaperito – **Nonfunctional** due to the lack of riparian vegetation along this reach of stream. There are a few thin-leaf alder sprouts establishing themselves near Cow Creek. The rest of the existing vegetation is from reseeding efforts (upland grasses) following the Viveash Fire and does not have root masses capable of holding remaining soils.

Stream Flow

Stream discharge was recorded by field crews on two (2) dates on Cow Creek at the same location in Reach 8 on the Martin Ranch using a Swoffer Model 3000 Current Velocity and Stream Discharge Indicator. The first measure was recorded during a high flow the day following a large rain event, the second measure was recorded at a lower base flow one week later following a period with no rain. Figure 2 displays the stream depth profiles used in calculating discharge. Stream depth and velocity were measured at two-foot intervals.

Figure 2. Stream depth profile for discharge on August 14 and August 21, 2001.



Stream discharge on the August 14th measurement was 42.5 CFS, just below the bankfull level; discharge on August 21st was 9.9 CFS. Photos 5 and 6 were taken the same days as the flow measurements, and illustrate the differences in stream discharge. The second photo was taken approximately 1100 feet upstream from the first in a similar riffle.

Stream discharge was recorded at 3 locations on Cow Creek during a 1989 Santa Fe National Forest fisheries habitat survey. Table 13 below lists the results of those flow measures related to the 2001 habitat inventory's reach designations (for locations, see Figure 6).

Photo 6. Reach 8, NSO 130, R53. Stream discharge of 42.5 CFS the day after a rain event (14 Aug 2001).

Photo 7. Reach 8, NSO 136, R56. Stream discharge of 9.9 CFS one week later following days without rain, taken just upstream from Photo 6 in a similar habitat (21 Aug 2001).

Table 12. 1989 fisheries habitat survey flow measures related to 2001 reach designations.

1989 Location Designation	Date	Method	Discharge (CFS)	2001 Reach Designation
Station 117, Upper Cow Creek	6/14/1989	Visual estimate	1.5	11
Station 118, Cow Creek Campground	6/19/1989	Float	5.0	7
Station 119, Lower Cow Creek	11/1/1989	Visual estimate	3.5	1

Of the three measures, the Cow Creek Campground station is closest to where discharge was measured in the 2001 survey. The 1989 float measure was taken approximately 2 miles downstream from the 2001 flow meter measurements. It should be noted that the accuracy of these estimates makes them unreliable data for comparison. Visual estimates are entirely unreliable; whereas float methods generally are only accurate to within $\pm$20% of the actual velocity in a natural stream (Trimmer 1994).

Peak flows in Cow Creek are generally governed by snowmelt, typically peaking in May to June. Cow Creek has a second peak in late summer to early fall, when the area receives seasonal monsoon events.

Water Temperature

Water temperature is a key aspect of the water quality in a stream environment. Combinations of multiple factors determine water temperature regimes in stream habitats. Solar Radiation, air temperature, riparian vegetation cover, ground water, stream discharge, channel shape, orientation, and climate are some of the major factors that influence water temperature. Many chemical and biological processes depend on specific temperatures. For many reasons, temperature can determine the suitability of waters for aquatic species such as the Rio Grande cutthroat trout (RGCT).

Fish growth, health and reproduction are also affected by water temperature. Fish are very sensitive to water temperature due to temperature specific enzymes. As water temperature increases, so does fish performance. Although fish have increased performance with temperature, they also approach a lethal limit. No lethal temperature information is currently available for RGCT, so information must be related from other species like the lahontan cutthroat trout (*Oncorhynchus clarki henshawi)*. The lahontan cutthroat trout had a 100% survival rate at 75.2 °F, but declined to 35% at 78.8 °F. Mortality was 100% within 48 hours at 82.4 °F. The upper limit for growth and long-term survival is somewhere between 71.6 and 73.4 °F. For this analysis, 73.4 °F will be considered the upper limit for survival of RGCT populations. These temperature limits were based on optimal conditions with high food availability and good water quality, not taking into account the other stressors that may exist in stream environments. It is possible that the actual lethal limits are lower due to water chemistry and other environmental factors (Dunham 1999).

Cutthroat trout reproduction is also affected by temperature. Smith et al (1983) compared egg quality of cutthroat trout in a variety of water temperatures. Eggs in cold water were expelled easily and were in good condition. In warm water the eggs were expelled with difficulty, were cloudy or opaque and often broken. Eggs spawned from two-year-old adults exhibited 74% viability in the coldwater while in warm water only 6.9%.

Four Onset Stowaway Recording Tidbit thermographs were placed in Cow Creek in July of 2001. Three of the four tidbits were placed within the survey area on Forest Service managed land. The fourth tidbit was placed in Reach 1 below the mouth of Bull Creek on private land. Thermographs were attached to 18” rebar stakes with bailing wire and were driven into the streambed so that the rebar was not visible above the water surface. Rebar stakes were placed in shaded areas near stream banks in firm sediment. Tidbits were downloaded in the field in October 2001 and May 2002 using an optical shuttle. After downloading, they were returned to the stream.

Figure 3. Stowaway Tidbit Thermograph (actual size)

One of the thermographs (lower end of Reach 5) was not located after installation. It is possible that the thermograph is still in place, but is buried under several feet of fine sediment.

Thermographs were set to record for one year, resulting in a temperature being recorded every 16 minutes. Tidbits were placed in Reaches 1 (Road 83 crossing, 6876' elevation), 5 (Road 86 crossing, 7848'), 7 (above Cow Creek Campground, ~8400'), and 10 (above Elk Creek mouth, ~9200') and were not moved during the duration of their recording. Table 14 details the locations of each Tidbit and the number of days the stream met the 3-day and 7-day average maximum temperatures as related to properly functioning condition for state coldwater standards and salmonids development.

Table 13. Water temperatures for Cow Creek from Tidbit Thermographs.

Location	Start Date	End Date	3-Day Max Properly Functioning	3-Day Max At Risk	3-Day Max Not Properly Functioning	7-Day Max Properly Functioning	7-Day Max At Risk	7-Day Max Not Properly Functioning
Upper Cow Creek (Reach 10)	7/11/2001	4/30/2002	294 days	0 days	0 days	294 days	0 days	0 days
Middle Cow Creek (Reach 7)	7/11/2001	4/30/2002	294 days	0 days	0 days	294 days	0 days	0 days
Cow below Bull (Reach 1)	7/11/2001	4/30/2002	287 days	7 days	0 days	267 days	27 days	0 days
Properly Functioning Indicators			<68° F	68-73.4° F	≥73.4° F	≤64° F	64-70° F	>70° F

Reach 1 is **At Risk** for both state coldwater standards and salmonids development. Reaches 7 and 10 are considered **Properly Functioning** for both state 3-day and salmonid development 7-day temperature standards. Reach 1 is located below Bull Creek, approximately 5 miles downstream from the start of the 2001 Cow Creek stream inventory on private property and below Forest Service land. The increase in temperature in Reach 1 is due to a combination of the drop in elevation and lack of stream shading in the area. In Reach 1, Cow Creek is wide with mostly shrubs lining the banks, leaving a large surface area exposed to direct sunlight. Monthly average temperatures for the Cow Creek similarly correspond to changes in elevation as expected. In order to determine the furthest downstream temperatures within Forest Service management, a tidbit should be placed in Reach 2 in future years.

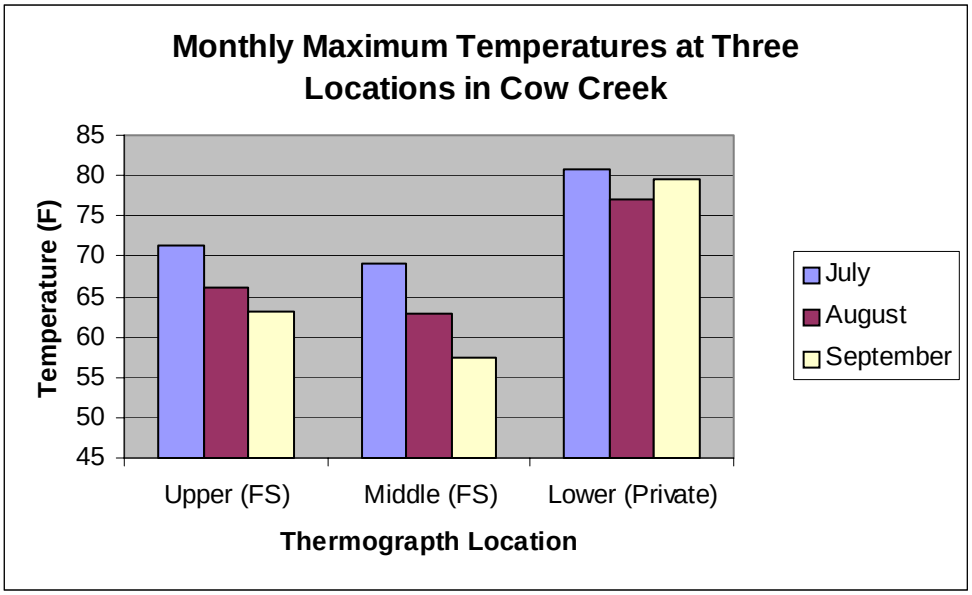
Table 14. Summer Monthly temperatures for Cow Creek thermograph sites in 2001 (°F).

	Upper Cow Creek (Forest Service Managed)				Middle Cow Creek (Forest Service Managed)				Cow Below Bull (Private Land)			
Month	Max	Min	Avg	Diurnal Avg	Max	Min	Avg	Diurnal Avg	Max	Min	Avg	Diurnal Avg
July	71.4	39.0	54.2	18.4	69.1	50.9	58.3	11.6	80.9	50.9	66.7	12.3
August	66.1	42.7	50.8	14.2	63.0	47.3	54.1	6.7	77.0	44.7	61.5	11.3
September	63.2	36.2	47.5	16.4	57.3	42.5	50.2	7.4	79.6	46.7	57.4	13.4

Diurnal temperature fluctuations were greatest at the upper Cow Creek thermograph station (see Figure 5). The headwaters of Cow Creek are a meadow system with little cover, thus even though the area experiences colder temperatures due to elevation (lower

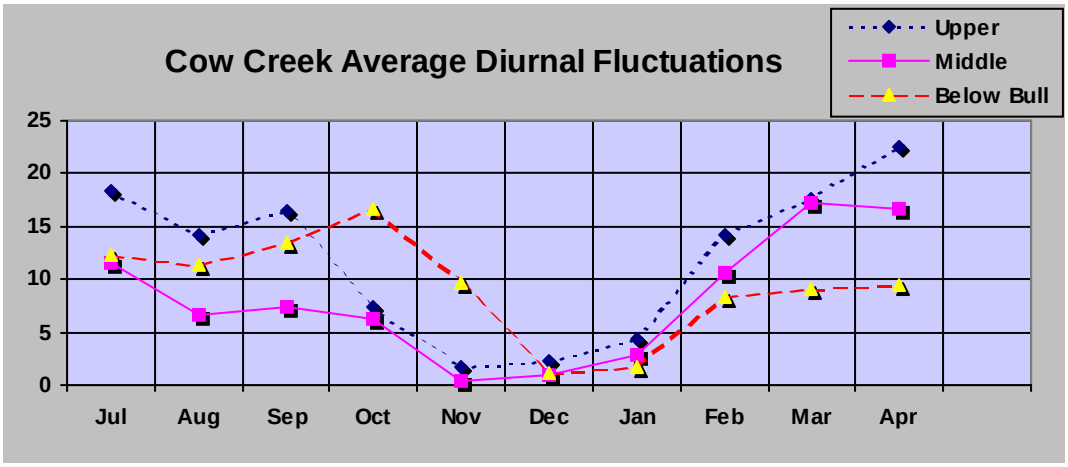
minimums), the lack of shading allows the area to rapidly warm up every day. The middle Cow Creek station had the lowest diurnal fluctuations, as would be expected. Canopy cover is high in this area, providing a large amount of shade. Below the mouth of Bull Creek, canopy cover is sparse, producing very high maximum temperatures (see Figure 4), with little cooling off due to low elevation.

Figure 4. Summer Maximum Temperatures at the Thermograph Stations on Cow Creek



The minimum temperatures in July 2001 for each site occur on July 13th in the afternoon, apparently the result of a cold precipitation event (i.e., a summer hail storm) in the headwaters of the stream. Temperatures in upper Cow Creek dropped from 60.31°F at 12:32pm to 39.0°F at 1:04pm (a decrease of 21.3° in 32 minutes), climbing back to 50.5°F by 2:40pm. A little over 14 miles downstream, at the thermograph below Bull Creek, temperatures dropped from 70.1°F at 3:44pm to 50.9°F at 5:36pm (a decrease of 19.2° in 112 minutes). This is an excellent example of the intense and far reaching effects a short duration weather event can have on stream temperatures.

Figure 5. Monthly average diurnal fluctuation for thermograph sites on Cow Creek.



Riparian and Upland Watershed Vegetation

The riparian areas of Cow Creek are dominated by willow, alder, and sedge species. Prior to the fire, most of Cow Creek had stable banks with good vegetative cover. There was no apparent down cutting throughout the stream, and riparian species were regenerating on suitable sites. Pre-fire vegetation had a diversity of riparian types, ranging from grass-dominated meadows, deciduous trees and shrub communities, and coniferous forests. Higher elevations were dominated by spruce/fir communities and were comprised of Englemann spruce *(Picea englemanni)*, corkbark fir *(Abies lasicarpa* var. *Arizonica)*, white fir *(Abies concolor)*, and quaking aspen (*Populus tremuloides*). Mid-slope positions were dominated by a mixed conifer type of white fir, Douglas-fir *(Pseudotsuga menziessi)*, southwestern white pine *(Pinus strobiformis)*, and ponderosa pine *(Pinus ponderosa)*. The lower slopes were characterized by ponderosa pine and gambel oak (*Quercus gambelii*) communities. Intermingled throughout the watershed were aspen stands, most of which were overmature, and a significant conifer component.

During the Viveash Fire, spruce-fir and mixed conifer types burned with the highest severity. These types represented much of the old growth habitat of the area. As expected, riparian areas and grasslands burned with low severity (USFS 2000).

Table 15. Viveash fire burn acreages and intensities by vegetation type.

Vegetation Type	High Severity		Moderate Severity		Low / Unburned		Total
	Acres	%	Acres	%	Acres	%	
Mixed Conifer	6584	60.0	2375	21.5	2042	18.5	11001
Riparian	14	7.0	3	1.5	185	91.5	202
Grassland	133	12.0	5	0.5	961	87.5	1099
Bristlecone Pine	75	10.5	0	0.0	631	89.5	706
Spruce-Fir	6775	49.0	120	1.0	6848	50.0	13743
Ponderosa Pine	387	25.5	697	45.5	445	29.0	1529
Oak Pine	73	29.5	0	0.0	175	70.5	248
Other	2	0.5	4	1.0	484	98.5	490
Total	14044	-	3205	-	11769	-	29018

Beaver Activity

There were no active or historic beaver dams located during the 2001 stream inventory. No indications of recent beaver presence were found throughout Cow Creek.

While the beaver's role in a watershed has been misunderstood by the public, land managers and biologists, studies over the last few decades conclude that beaver are a critical component to increasing stream integrity as well as biotic productivity within the stream and floodplain. Historically, beaver dams were methodically removed from streams on public land (FS Files).

Beavers have many affects on stream systems, surrounding riparian vegetation, and fisheries populations. Beaver caused stream impacts are considered to be generally beneficial to trout habitat and an asset to stream systems.

Beaver activity and its associated ponds have many affects on stream water quality, most of which are considered beneficial to trout habitat. The decreased stream velocity that occurs in pool habitat, such as beaver dams, decreases the waters ability to carry sediment suspended in the water column. Suspended sediment tends to settle into a pond's substrate, creating a sink for stream sediment and reducing turbidity. Sediment transport has been reduced by as much as ninety percent in studied streams (Olson 1994). Nitrogen and phosphorus containing sediments also settle, making beaver ponds a nutrient sink for a stream system. The storage of nutrient laden soil in sediment reduces eutrophication in nutrient rich systems. In low nutrient systems, such as headwater streams, the nutrient storage in pond sediment creates a time-release system increasing productivity. After the beaver leaves an area and the pond drains, the nutrient rich soil is utilized by riparian vegetation to produce dense riparian areas.

Decreased water velocity caused by beaver ponds alters the carbon cycle of streams. Reduced water velocity combined with increased water temperatures allows macroinvertebrates and bacteria to break down organic matter (leaves and wood) at a faster rate, creating dense macroinvertebrate populations. The breakdown converts organic matter to sediment and in some cases methane gas. The increased bacterial action reduces dissolved oxygen levels within the ponds and immediately downstream. The decreased velocity combined with increased width and overall surface area of the beaver ponds increases stream temperatures. The reduced concentration of dissolved oxygen and increased temperatures usually does not reach levels of concern for trout in Rocky Mountain streams (Gard 1961).

Beaver activity also has an affect on the riparian vegetation within proximity of the ponds, as well as the water table. Beaver activity increases the surface area of ponds by several hundred times, which is highly influential on the surrounding riparian vegetation. The increased surface area allows for storage of water in the banks and floodplain. The storage of water in the soil and floodplain increases the water table and stores water for times of low flow. During late summer low flow conditions water stored in the banks provides cool water to moderate flow and extreme temperatures (Parker et al. 1985).

While storing water, beaver dams also reduce extreme flows and related disturbance. The dams moderate flow during flood periods. This moderation reduces bank erosion related to flood events, improving bank stability in downstream areas (Olson 1994).

Beavers do consume large quantities of riparian vegetation or woody supplies in their diet, as well as for the construction and maintenance of their habitat. Consumption rates for beaver populations are higher than the regeneration rates of riparian vegetation. Beaver tend to occupy an area until the surrounding supplies are consumed and then move on to a new section of river within or outside of the watershed. Once a beaver leaves, high nutrient content in the area allows for fast regeneration of consumed riparian vegetation. Over time the area will regenerate and will be ready for a beaver to return in future years (DeByle 1985).

Beavers generally improve trout habitat. Cutthroat trout in Rocky Mountain streams tend to be most abundant in streams with beaver ponds, but are generally absent in streams with only abandoned ponds. Beavers do several things for fisheries habitat: provide a food source, moderate stream temperatures, as well as increase habitat volume and over wintering habitat. Trout biomass and individual size increases with the presence of beaver dams. One possible explanation is high density of macroinvertebrates involved in the decomposition of organic matter and consumption of bacteria. Macroinvertebrates are a key food source for many trout, including RGCT. Increased pool volume, a vital habitat feature for trout, could also contribute to the correlation of healthy fish populations and beaver ponds. Over wintering habitat is also provided by the deep pools created by some ponds. The deeper pools become a refuge for fish when riffle habitat is frozen and can determine the carrying capacity of a stream. Flow and water temperature moderating affects that are caused by increased water tables provide cool water to the stream during low flow conditions. This could further increase the fish population carrying capacity of the stream (Olson 1994).

From an aquatic resource perspective, it is desirable to allow beavers to colonize the Cow Creek Watershed. Beaver activity should be monitored over time especially as the watershed recovers.

Fisheries

Before the Viveash Fire, Cow Creek contained brown trout *(Salmo trutta)*, rainbow trout *(Oncorhynchus mykiss)*, longnose dace *(Rhinichthys cataractae)*, and Rio Grande Cutthroat trout *(Oncorhynchus clarki virginalis)*, the New Mexico state fish. Of these, only Rio Grande cutthroat trout and longnose dace are native to the drainage.

Photo 8. Rio Grande cutthroat trout captured in Reach 11 of Cow Creek during a backpack electrofishing spot survey (26 Jul 2002).

The introduction of non-native salmonids to Cow Creek resulted in Rio Grande cutthroat trout being confined to the headwaters of the system. The exact historic range of Rio Grande cutthroat trout is not known, though it most likely encompassed all fish-bearing waters in the Cow Creek Watershed downstream to the confluence with the Pecos River. However, our native trout readily hybridize with other spring spawning trout such as rainbow trout and other subspecies of cutthroat. With the risk of genetic loss through hybridization combined with competition from other introduced trout for food and space, it is imperative that exotic salmonids be excluded from Rio Grande cutthroat trout habitat (Sublette et al. 1990). Additional threats to Rio Grande cutthroat trout populations include habitat degradation and the dewatering of streams for irrigation use. Although it is not federally listed under the endangered species act at this time, the Rio Grande cutthroat trout is listed on the Regional Forester's list of sensitive species.

According to Sante Fe National Forest fishery files, from 1959 to 1964 a total of 76,464 rainbow trout, 111,945 brown trout, and 43,790 cutthroat were stocked in Cow Creek. Although records fail to identify the origin of the cutthroat used in stocking, they were most likely exotic Yellowstone cutthroat trout. Yellowstone cutthroat were stocked widely throughout New Mexico dating as early as 1902. Most cutthroat stocked in NM originated from Yellowstone Lake. Snake River cutthroat have also been introduced into 29 water bodies in New Mexico, including the Pecos River and its tributaries. Introductions of Snake River cutthroat began in 1976, and management for the subspecies still continues at many locations (Sublette et al. 1990).

In 1989, a fish survey crew from the Santa Fe National Forest electrofished three sites on Cow Creek. The three sites sampled in the 1989 survey are displayed on the Cow Creek map in Figure 6 to the right (also see Table 17).

Figure 6. 1989 survey site locations.

Table 16. Electrofishing results from three sites on Cow Creek in 1989.

Location	Date	Sample Length	Species Found	Total # Fish	# Fish > 6"	Total Weight	Total Weight > 6"
Station 117, Upper Cow Creek	6/19/1989	400'	RGCT	1	1	.2 lbs	.2 lbs
Station 118, Cow Creek Campground	6/14/1989	400'	Brown	94	60	9.75 lbs	8.92 lbs
Station 119, Lower Cow Creek	7/16/1989	400'	Brown	17	16	4.12 lbs	4.05 lbs

Following the Viveash Fire in June 2000, USFS and NMDG&F personnel removed 80-100 Rio Grande cutthroat trout from Cow Creek in Reaches 10 and 11 and transported them to the USFWS fish hatchery in Mora, NM. The combined agency crews were unable to remove all cutthroat, but at least removed some of the native fish before mortalities resulted from heavy ash flows. Photos 9 and 10 on the following page are from the recovery efforts made removing Rio Grande cutthroats from Cow Creek.

Photo 9. Ash flow in Cow Creek following the Viveash Fire (20 Jun 2000). Inset: Rio Grande cutthroat trout mortality due to an ash flow in Cow Creek during recovery efforts (5 Jul 2000).

Photo 10. Rio Grande cutthroat trout photographed before being transported from Cow Creek to the national fish hatchery at Mora, NM (5 Jul 2000).

During the 2001 stream inventory of Cow Creek, no fish were observed by the survey crews. A snorkel survey was performed in Reach 11 of Cow Creek. No fish were sighted during the snorkel survey, but the surveyor reported difficulty seeing under cut banks. The assumption was that no fish were present in the upper reaches of Cow Creek, but further verification was recommended. Also during this time, local residents reported sightings of brown trout in Reaches 5-7 of Cow Creek. Electrofishing efforts were conducted to verify fish presence, but no fish were located by Forest Service personnel at that time.

In September of 2001, personnel from NMED electrofished Cow Creek just upstream from the mouth of Bull Creek. Turbid conditions were such that fish were hard to locate and capture. The survey captured 2 brown trout and 4 longnose dace in an 80 meter long survey by dragging a seine behind the electrofisher (NMED Fisheries Files). Most likely these were fish that moved into Cow Creek from Bull Creek, as Bull was largely unaffected by the Viveash fire. Fish passage from Bull Creek into Cow Creek is possible, but barriers in Reach 3 prevent fish passage further upstream. Some potential barriers identified during the survey are natural formations that can be enhanced to prevent fish passage (see Photos 11 and 12).

Table 17. Potential natural barriers to fish passage in Cow Creek.

Reach	Habitat #	Type	Size	Barrier?	Comments
2	F1	Chute	14’ high, 7’ long	No	Very confined chute with large pool at base.
3	F2	Falls	12’ high	Yes	
3	F3	Falls	5’ high	No	During high flow passage possible around falls
3	F4	Falls	20’ high	Yes	
3	F5	Falls	6’ high	Yes	No pool present at base
3	F6	Falls	5’ high	Yes	No pool present
3	F7	Falls	8’ high	Yes	Chute at base of pool

9	F8	Falls	3’ high	Possible	Possible barrier due to structure, scattered debris at base
9	F9	Falls	4’ high	No	Large pool at base
10	F10	Falls	8’ high	No	Several pockets that could facilitate fish passage
10	F11	Fall / Chute	16’ high	Yes	9’ high falls with bedrock chute at bottom
10	F12	Falls	12’ high	Yes	
11	F13	Falls	4’ high	Possible	Very shallow splash depth

In July 2002 personnel from the Pecos/Las Vegas Ranger District conducted spot checks for fish presence using a backpack electrofisher. Numerous RGCT were located in Reaches 10 and 11 of Cow Creek. Fish captured varied in size class from juveniles to adults, and all fish appeared healthy. Due to a desire to minimize impact on the population, extensive electrofishing was not conducted in the area. During the spot check, no other species of fish were found. A more extensive snorkeling survey of the area was attempted in September 2002, but poor weather conditions prevented conducting a thorough survey. Genetic sampling by NMGF determined that Cow Creek RGCT are impure (Y. Paroz, personal communication, 2003). It is unclear as to the extent.

Photo 11. Reach 3, NSO 44, F4. 20’ waterfall preventing upstream fish passage into the rest of Cow Creek (29 Jul 2001).

Photo 12. Reach 10, NSO241, F11. Falls/chute complex, definite barrier to fish passage (28 Aug 2001).

During a thermograph removal at the lower end of Reach 10 (just above the mouth of Elk Creek) a brown trout adult was observed and identified in June 2002. This is the only brown trout sighting in Cow Creek by Forest Service personnel above the Reach 3 barrier since the aftermath of the Viveash Fire. This is below the falls in Reach 10.

With the apparent reduction of exotic fish in Cow Creek and the inability of colonizing fish from Bull Creek to get above the barriers in Reach 3, the Viveash Fire has presented a unique opportunity to restore RGCT throughout the majority of Cow Creek surveyed in the 2001 inventory. Although some treatment will still be required to remove the remaining exotic species in Reaches 3-10, it is an excellent opportunity to expand the range of our state fish in Cow Creek, resulting in 16 miles of occupied RGCT habitat.

Stream Improvements

According to USFS files, 42 stream improvement structures were installed in Cow Creek over 13.5 miles of Forest Service land and 6.0 miles of private land. Unfortunately, the document is incomplete and a date and type of structure are not included. Aside from this record, no data on stream improvements was located for the Cow Creek Watershed. During the 2001 stream inventory, no stream improvements were identified. It is likely that any structures that were in place were wiped out during post-fire floods.

Once stream flow dynamics have returned to a more stable flow regime, Cow Creek will be an excellent candidate for future stream improvement activities. It is imperative that the system is stable enough to sustain any improvements without the risk of a flood event destroying them. In particular, the lack of large woody debris in Cow Creek is of some concern. The potential for natural recruitment of LWD resulting from the disturbance caused by the Viveash Fire should be taken into consideration before any plans are made to supplement wood in the Cow Creek system.

LAND USE

The Cow Creek Watershed lies within the Upper Pecos Valley culture area. Paleo-indian (9,500 B.C. – 5500 B.C.) use of the upper Pecos valley appears to have been minimal. Increased hunting of small game in the area began in the Archaic Period and continued into the Basketmaker/Pueblo I Period (A.D. 1-900). The first known sedentary community in the upper Pecos valley was occupied in approximately A.D. 800 near the present Pecos Pueblo. The community used maize, wild plants, mule deer, antelope, and agricultural fields in the area. About A.D. 1200, population size increased. Farming and hunting and gathering continued to be the economic base of the valley. Outlying fields expanded agricultural land to boost crop production.

By the Pueblo IV Period (A.D. 1300-1600), large multi-storied communities were thriving. Irrigation was employed for agricultural production and the valley was a well-known trade center (Nordby 1981).

Coronado first visited Pecos Pueblo in 1540, and several other expeditions followed between 1581 and 1598 (Jenkins and Schroeder 1974). By the 1790's, Spanish settlers began to use the area. In the early 1800's there were several hundred families within the river valley. Trade between the United States and Mexico was established by 1822, and the Santa Fe Trail passed through the Pecos area and Glorieta Pass. In 1846 New Mexico became a United States territory. Since that time the area has been exploited by both Anglo and Hispanic populations for the timber, mineral, and grazing resources available (Meining 1971).

A variety of land use practices occur in the Cow Creek Watershed.

Roads

There are 521 roads or road segments listed in the SFNF GIS layer within the Cow Creek 5th HUC Watershed. The majority of roads within the 5th code Cow Creek Watershed (HUC 1306000102) fall outside the survey area, downstream from t

area, leaving the majority of the proposed clear cut areas untouched (C. Napp, personal communication, 2002).

A salvage timber sale is currently proposed for a portion of the fire-killed trees in the Viveash Fire area. The proposed alternative of the Viveash Fire Salvage Environmental Impact Statement calls harvesting fire-killed trees on approximately 6,700 acres of the 29,000-acre area burned in the Viveash Fire. More information on the proposed salvage sale can be found in the EIS (USFS 2002).

As has been discussed above, large woody debris is largely absent from Cow Creek. For aquatic resource and floodplain protection, future recommendations for timber management in the Cow Creek Watershed should be to manage riparian, floodplain and adjacent slopes as potential sources of LWD and to protect natural soil conditions. Harvesting of timber within 300' of live water should meet this objective. While this is a general statement, there are site-specific opportunities to conduct riparian thinning inside this buffer. In order to achieve this objective and assure large woody debris remains in the floodplain, firewood collection should be excluded from within this buffer.

Fires

Fire is an important ecosystem process in the forests of New Mexico. Historically, the natural fire regime of the southwest typically consisted of two cycles: Low intensity burns in low elevations at intervals ranging from 7 to 25 years; and high intensity burns in high elevation spruce/fir forest types occurring every 100-250 years.

Due to past fire suppression, however, the accumulation of fuels in our forests has changed fire regimes such that fires now frequently have the potential to become intense, catastrophic burns. One such intense burn was the Viveash Fire of 2000.

Photo 13. The Viveash Fire on May 30th, 2000. The fire consumed 20,000 acres that day.

The Viveash Fire burned approximately 29,000 acres in the Cow Creek, Bull Creek, and Gallinas Watersheds between May 29th and June 9th. The majority of the area (~20,000 acres) was burned on May 30th when fire behavior was extreme as a result of a fuel-driven crown fire. The fire that day was characterized by a plume-dominated smoke column climbing to an elevation of over 20,000 feet above ground level. Spot fires occurred ½ mile to 1 mile ahead of the main fire (USFS 2000).

Cow Creek was the primary watershed affected by the Viveash Fire. The Gallinas Watershed was also affected, but to a much lesser extent. Prior to the fire there was little evidence of erosion. Increases in sedimentation, mass erosion, and turbidity are the most serious threats to water resources following wildfire.

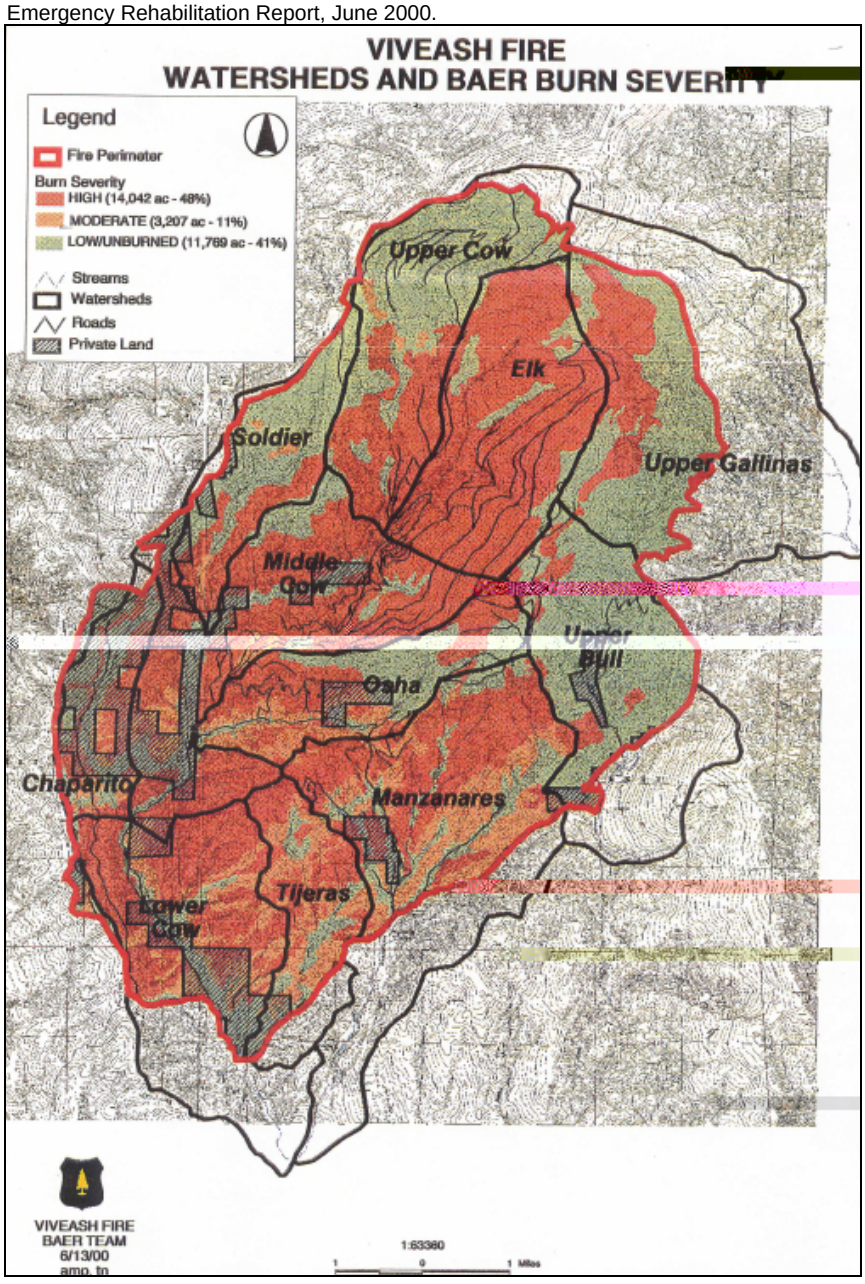
Wildfire influences erosion most obviously by removing vegetation that would act to slow and absorb precipitation and overland flow, and stabilize the soil with its root masses. Fire creates hydrophobic soils, greatly reducing water infiltration. Water falling directly on soil has the effect of compacting it, further reducing permeability and infiltration. Vegetation acts to lessen this by intercepting precipitation and absorbing the resulting impact, and sending it on to the soil with a greatly reduced force, which increases infiltration and reduces erosion. Vegetation also slows down the overland flow of water, also reducing erosion and increasing infiltration.

Photo 14. Viveash Fire in the Cow Creek Watershed. (Inset) Smoke column as seen from the Forest Service Pecos Ranger District office.

Perhaps the most notable aspect of the Viveash Fire was the intensity with which it burned. Burn severity was extremely high for most of the Cow Creek Watershed (see Figure 8).

Large fires of high severity such as Viveash have the greatest potential for destabilizing normal hydrologic functioning. The Viveash Fire burned with great intensity (see Table 19). The Viveash Fire occurred just as buds were beginning to develop on conifers. This intense burn severity, combined with the timing early in the growing season, led to high tree mortality within the burned area. Stand-level mortality occurred under nearly all stand conditions with the exception of pure aspen and riparian stands (USFS 2000).

Figure 8. Extent and severity of the Viveash Fire, from the Viveash Burned Area Emergency Rehabilitation Report, June 2000.



Terrestrial wildlife within the Viveash Fire area was impacted by habitat destruction if they survived the fire. Teams noted several burned wildlife carcasses shortly after the fire. However, most large mammals and birds are thought to have escaped the fire and were displaced to adjacent areas. There is a long-term loss of habitat for old growth species such as goshawk and the Mexican spotted owl. In the long run, habitat diversity within the burned area is expected to increase. Dense timber snags have been opened up to create more diverse habitats such as meadows, aspen stands, and early seral forests (USFS 2000).

Table 18. Burn severity by subwatershed (from the 2000 Viveash BAER Report).

Subwatershed	High Burn Severity	Moderate Burn Severity	Low Burn Severity and Unburned	Total Percent Burned
Lower Cow	40	15	12	67
Middle Cow	72	5	22	99
Upper Cow	32	2	58	100
Tijeras	30	33	18	81
Manzanares	31	20	15	65
Osha	42	20	38	100
Chaparito	41	10	46	97
Soldier	26	3	65	94
Elk	90	0	10	100
Upper Bull	7	1	60	67
Cow Creek Total	**42**	**10**	**31**	**83**

Aquatic species were impacted heavily by increased runoff and sediment production, as discussed under Fisheries. There could continue to be impacts to aquatic organisms for a number of years. The re-colonization of aquatic macroinvertebrates has been proposed for a; this would give great insight to the recovery and stability of the Cow Creek system. Invertebrate populations should be abundant and stable before fish re-introduction into Cow Creek is considered.

In light of the Viveash Fire, the effects of any previous fires on the Cow Creek Watershed are largely irrelevant. The intensity of the effects of the fire should decrease over the next few years as re-vegetation occurs.

Grazing

Overall, the grazing allotments within the Cow Creek Watershed permit 275 livestock to graze on 51,573 acres, with 7,500 capable acres (USFS Files). However, this permitted number is far greater than the actual use in the watershed. Grazing numbers have been significantly reduced since the Viveash Fire. In addition, these allotments cover more area than just the Cow Creek Watershed. Estimates of actual use are 50% to 75% of permitted use. The grazing season in Cow Creek is generally from June 1st through October 15th (K. Brown, personal communication, 2002).

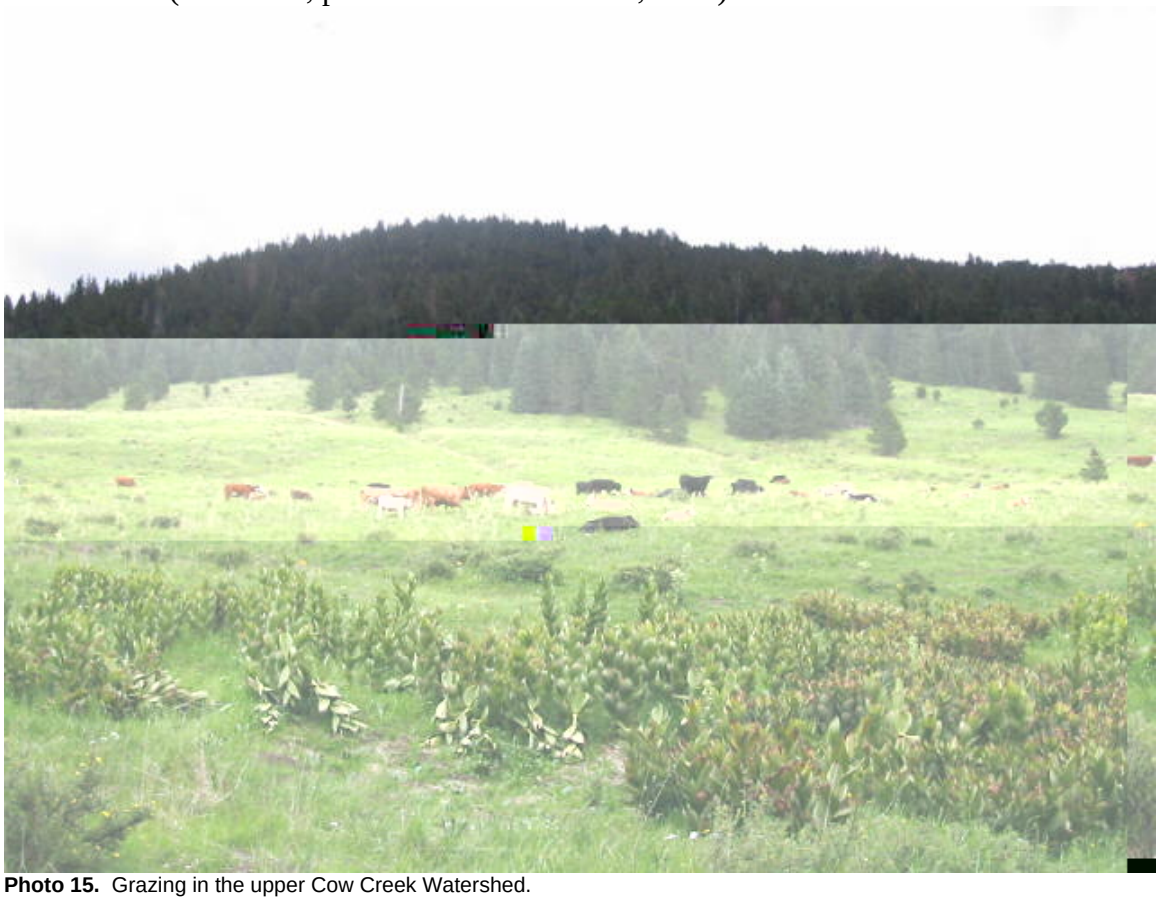


Photo 15. Grazing in the upper Cow Creek Watershed.

There are five grazing allotments within the Cow Creek Watershed survey area on Forest Service land:

- Rosilla: The Rosilla allotment covers 16,831 acres, 5150 of which are capable of sustaining grazing. Permitted numbers are 132 cows and 12 bulls from June 16 to September 30. Rosilla is under a deferred rotation grazing system. The southeast quarter of the Rosilla allotment was severely burned in the Viveash Fire. The result of this high intensity burn is a greater number of openings, allowing more sunlight and precipitation to reach the forest floor. Coupled with re-seeding efforts, the capable acreage has increased substantially, allowing better distribution of cattle throughout the allotment. Rosilla also supports 18 horses/mules from June 1 to October 15.

- Soldier Creek: The Soldier Creek allotment is composed of intermingled public and private land. Of the 8503 acres within the allotment boundary, only 3650 are within the National Forest System (NFS). Within the NFS, 940 acres are capable of sustaining grazing. Soldier is allotted 5 head of cattle from July 1 through October 31. However, the Soldier Creek allotment is currently inactive. A small portion of the east side of the Soldier Creek allotment was severely burned.

- Valle Osha: The Valle Osha allotment consists of 4407 acres, of which 288 acres are capable of sustaining grazing. 77 cattle are permitted to graze from June 1 to September 30 on this allotment. Much of the Valle Osha allotment was within the severely burned area.

- Cow Creek: The Cow Creek allotment covers 6301 acres, 677 of which are capable of sustaining grazing. 11 head of livestock are authorized to graze from May 16 through October 15 on this allotment, most of which burned with a moderate to severe rating.

- Colonias: The Colonias allotment consists of 20,384 total acres, 445 of which are capable of sustaining grazing. This allotment permits 20 head of livestock from March 1 through May 31. The Colonias allotment was not within the area burned by the Viveash Fire.

Although grazing is not having a significant impact on Cow Creek, there is minor damage being done in upper Cow Creek where RGCT were found. Riparian use by cattle was observed to be highest in this area in 2002. In 2001, no cattle were observed in this area. It is recommended that cattle use in upper Cow Creek be monitored to determine effects grazing may have on floodplain function, riparian integrity and stream productivity.

Recreation

The Cow Creek Watershed has been the major recreational area for the local community for many years. With increased tourism in the Pecos Canyon, locals shifted their use to Cow Creek for recreation opportunities. The community uses this area for dispersed camping and family gatherings on weekends generally from May through October. Cow Creek and the Osha Watershed were important fisheries for the community before the Viveash Fire.

The Viveash Fire had major impacts on the recreation opportunities in the Cow Creek Watershed. Recreation areas were damaged during the fire and the quality of recreation has been diminished (USFS 2000). In addition, roads throughout the watershed continued to wash out in 2001 presenting an obstacle to recreational use.

There is one developed campground in the watershed: Cow Creek Campground. In 2001, the campground was open for 187 days and accommodated 2342 visitors, an average of 12.5 people per day. The Cow Creek Watershed has no developed trails. There are numerous user-created trails on Forest Service and private lands along the stream (J. Buehler, personal communication, 2002).

RECOMMENDATION SUMMARY

The greatest need in the Cow Creek Watershed over the next few years is monitoring. Little more can be done until the system has recovered from the Viveash Fire. Once the area has started to reach an ecological equilibrium, more accurate decisions can be made about management needs within Cow Creek. Also, with further monitoring, areas that aren't improving can be identified and steps can be taken to aid in the recovery process.

Cow Creek represents an opportunity for the restoration of native Rio Grande cutthroat trout (see Figure 9). Before Viveash, RGCT were confined to the headwaters of Cow Creek through competitive exclusion. Brown trout and rainbow trout were effective at out-competing RGCT for downstream habitats. Since the Viveash Fire, brown trout numbers have greatly declined and habitat has been made available for the reintroduction of Rio Grande cutthroat throughout a much larger portion of their historic range in the drainage. The remaining browns would have to be treated and removed, but the potential now exists to have cutthroat ranging from the 20' barrier identified in Reach 3 to the headwaters. The Reach 3 barrier should be effective at excluding exotic re-colonization from downstream in Cow Creek and in Bull Creek. Populations of brown trout in Bull Creek were largely unaffected by the Viveash fire and have already begun to re-colonize Cow Creek. However, they will be unable to move upstream past the waterfall in Reach 3.

Figure 9. Current (left) and proposed (right) RGCT habitat in Cow Creek.

One challenge in the expansion of RGCT range in Cow Creek that must be faced is the education of the public stakeholders in the area. Recovery efforts could be wasted if the public is not on board with the program. Education must be conducted so that anglers know that the area contains species with special regulations. Streamside land owners with ponds stocked with trout must be made aware of the need for the conservation of our

state fish. RGCT must be made available to land owners, so they can stock natives and reduce the risk of exotics once again making their way into the system. In order for the reintroduction to succeed, the public must know the 'why' of the program as well as the 'what' and 'how.' The opportunity presented in Cow Creek is too great to be nullified by a lack of interest on the public's part. Without public support, the accidental or intentional introduction of exotics above the barrier could easily result in situation similar to pre-Viveash, with RGCT once again confined to the headwaters of Cow Creek.

As of the finalization of this report, New Mexico Game & Fish has begun stocking (April 30, 2003) of rainbow trout in the potential re-introduction area (P. Wilkinson, personal communication).

Reach by Reach Recommendations:

- Reach 2: There is very little pool habitat within Reach 2. With fine substrates dominating pools at the time of the survey, this could very likely be a result of sediment collecting and filling in pools. It is recommended that pool habitat be monitored in the future. If fine sediment is not flushed out of pools, resulting in more pools and deeper residual depths, habitat improvement techniques could be utilized to improve pool habitat within the reach.

- Reach 3: Proposed as the lower limit for RGCT distribution. The recommended barrier in this reach should be examined to ensure its functionality, and other barriers downstream from the 20' waterfall should be examined for their utility as buffer barriers as well.

- Reach 4: The absence of pools, high percentage of unstable banks, lack of large woody debris, and large amount of fine sediment depostion within Reach 4 all seem to stem from private land management practices within the reach. As this Reach is outside of Forest Service control, discussion and recommendations regarding the land owners current management practices could be initiated. Even though we can't directly manage the area, perhaps some good advice to the current land owner would go a long way towards restoring this reach. Reach 4 is by far the least functioning reach surveyed in the 2001 stream inventory.

- Reach 5: As in Reach 4, Reach 5 is entirely outside of Forest Service control. However, it is recommended that discussion be initiated with private landowners once trees damaged in the Viveash Fire have begun to settle into the stream, to stress the importance of woody debris to fisheries and stream habitat. Reach 5 is in far better condition than Reach 4, but the distinct lack of pool habitat and low LWD numbers within the reach are a definite concern.

- Reach 7: Road 92 closely parallels Cow Creek throughout the reach. During the high volume runoff events following the Viveash Fire, the road often washed out in places, and served as a source of sediment into Cow Creek. It is recommended that the possible continuing effects of the road as a source of sediment input be examined in greater detail. Further analysis should be conducted to determine if

road re-alignment is feasible to pull the road away from the stream and out of the floodplain.

- Reach 8: Timber harvest was occurring between the road and the stream in Reach 8. While this is private land and beyond our management control, it is recommended that the land owners be made aware of the value of both standing trees and woody debris as stream resources.

- Reach 9: With Reach 9 being in a more heavily forested area, and one that experienced severe burn intensity, it is recommended that this reach be observed to monitor the introduction of LWD into Cow Creek. Reaches 9 and 10 will potentially serve as strong sources of LWD, which should then be transported by Cow Creek to downstream reaches.

- Reach 10: It is recommended that Reach 10 be more thoroughly surveyed to determine the lower end of RGCT range. It is suspected that the lower boundary for RGCT is the large fall/chute complex found in the reach, but a more thorough fish survey is needed to confirm that speculation.

- Reach 11: In Reach 11, as in Reach 10, RGCT distribution needs to be more thoroughly examined. The upper limit of RGCT range needs to be determined and, if possible, what limiting factor is keeping RGCT out of the upper end of the reach. In addition, cattle presence and the impacts on the stream channel need to be monitored in greater detail.

REACH SUMMARIES

Photo 16. Reach 9, NSO 186, R76. Breaking an NSO at a side channel (22 Aug 2001).

Reach 1: Private Land (Not Surveyed) – Mouth to upstream of North Colonias

Reach 1 begins at the confluence of Cow Creek with the Pecos River near Sands, New Mexico. From the mouth (T14N, R13E, Sec. 24 NE¼, elev. 6220') up to the end of the reach in T16N R13E Section 29 NE ¼, just over a mile north of North Colonias, Cow Creek flows approximately 11 miles through private land. Access to Cow Creek throughout this stretch was not obtained. Under the Region 3 Stream Inventory, areas that are not surveyed are still assigned a reach number. Thus Cow Creek below the start of the survey is designated as Reach 1.

The only data recorded in Reach 1 was temperature data (see Water Temperature section, Tables 14 and 15). Temperatures in Reach 1 were found to be **at risk** for stream proper functioning for both state standards and standards for salmonid development.

During the start of the Bull Creek stream inventory in September 2001, numerous brown trout were observed in Cow Creek near the mouth of Bull. These fish had most likely moved into Cow Creek from Bull Creek, which was far less impacted by the Viveash Fire.

Reach 2: Survey start to Manzanares Creek

Reach 2 begins on private land (T16N, R13E, Sec. 29 NE ¼) and progresses upstream 2.45 miles to the mouth of the Rito Manzanares, over a gradient of 3.4%. Reach 2 starts at 7280' and climbs upstream to 7680'. This reach is a Rosgen type B3 channel with cobble as the dominant substrate. Reach 2 is largely made up of Forest Service land, although the start and end of the reach are on private land. This reach was broken due to the amount of flow contributed by the Rito Manzanares. Reach 2 was surveyed from July 16 to 20, 2001, by C. Robertson (observer) and A. Bullock (recorder).

Reach 2 is within a fairly wide valley, narrowing as it nears the Rito Manzanares. Riparian vegetation within the reach consists largely of grasses, sedges, rushes, speckled alder, willow, gambel oak, and conifers. Upland vegetation is mainly composed of conifers, oak, and grasses.

Photo 17. Chute / waterfall in Reach 2. Due to the pool depth, surveyors determined it is not a barrier to fish passage (Reach 2, NSO20, F1, 18 Jul 2002).

Water temperatures were recorded with grab samples throughout the stream survey process. Temperatures were recorded at the first and last NSO of every day, and at every tenth riffle and pool. The average temperature of 64.6°F falls within the desirable range for RGCT of <64-68°F, although the one-time max of 69°F is an indication of higher temperatures, a little high for long-term survival of RGCT.

Table 19. Water temperatures calculated from grab samples in Reach 2, 16 –20 Jul 2001.

Reach	Number of Samples	Max Temp	Min Temp[1]	Avg Temp[2]
2	6	69°F	57°F	64.6°F

[1]The minimum temperature shown is only the minimum recorded when the crew was in the field (times recorded with temperatures range from 0912-1635 hours). Nighttime temperatures were likely lower than those observed during the survey.
[2]The average temperature shown is not a true average temperature, as it only averages the grab samples recorded when the crew was in the field in Reach 2.

Habitat Characteristics

Reach 2 of Cow Creek was broken into 31 individual NSO's. Of these 31 NSO's, Reach 2 was composed of 13 pools, 13 riffles, 3 tributaries, 1 side channel, and 1 waterfall (see Table 20). Although the pool to riffle ratio in the reach is 1:1 (see Table 23), only 3.3 percent of the habitat in Reach 2 is pool habitat. Riffle habitat comprises 95% of the reach, almost 29 times more than pool habitat. With far less than 30% of habitat in pools, Reach 2 is **not properly functioning** for pool development.

Table 20. Overall stream summary for Reach 2.

Reach 2					
Stream Length Surveyed: 2.45 miles (12,850')		**Gradient**: 3.4%		**Rosgen Channel Type:** B3	
Habitat Type	**Number**	**Total Feet of Stream Habitat**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	13	435	3.4	3.3	>30%
Riffle	13	12415	96.6	95.0	-
Culvert	0	-	-	-	-
Tributary	3	-	-	-	-
Falls	1	14	0.1	0.1	-
Side Channel	1	200	-	1.5	-
Total	31	13064	100	100	-

Riffles in Reach 2 were consistent with a Rosgen B3 channel type. Reach 2 of Cow Creek was found to be **not properly functioning** for stream sediment, having greater than 20% fines in riffles (see Table 21). Cobble was the dominant substrate type in riffles in Reach 2.

Table 21. Summary o

Table 22. Summary of habitat and substrate percentages for pools in Reach 2 of Cow Creek.

Reach 2 Pool Habitat Summary											
	# Pools	Avg Length	Avg Width	Avg Max Depth	Avg PTC	Avg Residual Depth	Pools per Mile	# Pools w/ Residual Depth ≥1'	Pools w/ Residual Depth ≥1' per Mile	# Pools w/ Max Depth ≥3'	Pools w/ Residual Depth ≥3' per mile
Reach 2	13	33.5	16.2	2.7	0.8	1.9	5.3	12	4.9	4	1.6
Properly Functioning Indicators	-	-	-	-	-	≥1'	-	-	-	-	-

Substrate Summary					
	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock
Reach 2	36.2	23.1	13.8	13.8	13.1

Reach 2 was found to be **properly functioning** for pool quality, with the average residual depth of pools being 1.9 feet. Of the 13 pools in Reach 2, 12 had residual depths of 1' or greater. Four of the pools present had residual depths of 3' or greater (see Table 22). Although the quality of pools in Reach 2 was sufficient, the quantity of pool habitat was very low with only 3.3% of habitat in pools as stated above. Sand was the dominant substrate type in pools in Reach 2. The high amount of fines in pools is primarily due to erosion upstream from the Viveash Fire. Although Reach 2 was largely outside the burned area, it still suffers from the effects of the fire in the watershed.

Reach 2 was **not properly functioning** for large woody debris, having a meager 1.6 pieces of LWD per mile (see Table 23). In order to be properly functioning, greater than 30 pieces of LWD per mile are required. The lack of LWD in Reach 2 is due to a combination of past fire suppression and severe flooding since the Viveash Fire. Past fire suppression efforts have effectively removed a form of disturbance necessary for LWD recruitment in Cow Creek, although the disturbance produced by the Viveash Fire will likely aid in LWD recruitment in the future. In addition, any LWD that was in place had to withstand the violent flood conditions that followed the Viveash Fire. It is suspected that several pieces may have been washed out during flooding in 2000 and 2001. Reach 2 was subject to extreme flood conditions during both years.

Table 23. Habitat characteristics for Reach 2.

	Pool:Riffle Ratio	Bankfull Width:Depth Ratio	Pieces of LWD per Mile	Total Feet Unstable	% Banks Unstable
Reach 2	1:1	16:1	1.6	275	1.1
Properly Functioning Indicators	-	12<30:1	>30	-	<10

The bankfull width to depth ratio of 16:1 is **properly functioning** for Rosgen's type B channel. Bank stability in Reach 2 was **properly functioning**, with a mere 1.1% of banks being unstable within the reach (see Table 23).

As stated above, there is very little pool habitat within Reach 2 (see Table 20). With fine substrates (sand, silt, and clay) dominating pools at the time of the survey, this could very likely be a result of sediment collecting and filling in pools. Residual pool depth in the reach was only 1.9 feet, another indicator that pools may be filling in with sediment. The large amount of fines in riffle habitats (23.8%) reinforces that there may be a sediment deposition problem within Reach 2. It is recommended that pool habitat in Reach 2 be monitored in the future. If fine sediment is not flushed out of pools, resulting in more pools and deeper residual depths, habitat improvement techniques could be utilized to improve pool habitat within the reach.

Reach 3: Manzanares Creek to Valdez Bridge

Reach 3 begins at Manzanares Creek on private land (T16N, R13E, Sec. 18 NE ¼) and progresses upstream 0.78 miles to Valdez Bridge, over a gradient of 4.9%. Reach 3 starts at 7680' and climbs upstream to 7880'. This reach is a Rosgen type A1 channel with bedrock as the dominant substrate. Reach 3 flows entirely through private land. Reach 3 was broken due to decreases in valley confinement and stream gradient. Reach 3 was surveyed from July 20 to 21 by C. Robertson (observer) and A. Bolick (recorder).

Reach 3 is in a fairly wide valley. The riparian community is composed of grasses, rushes, sedges, willow, alder, and conifer species. Upland species include grasses, oak, and conifers.

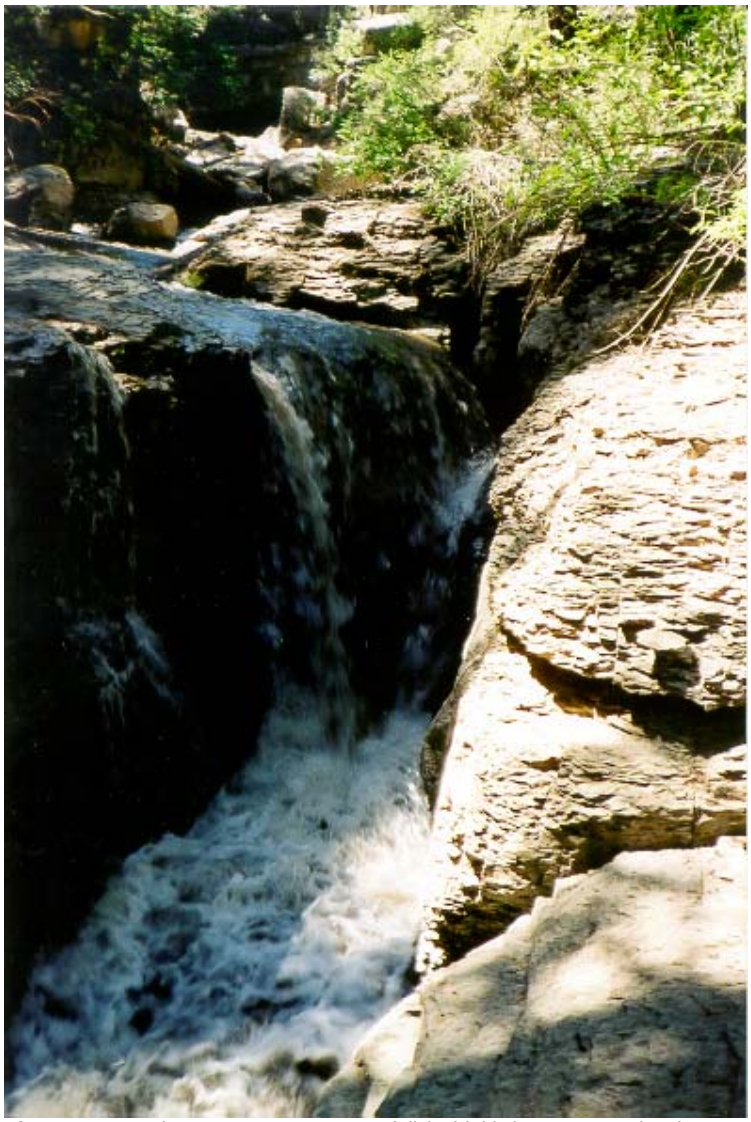


Photo 18. Reach 3, NSO50, F7. Waterfall (8' high) that acts as a barrier to fish passage due to its confined channel and shallow depth at splash (30 Jul 2001).

Table 24. Water temperatures calculated from grab samples in Reach 3.

Reach	Number of Samples	Max Temp	Min Temp[1]	Avg Temp[2]
3	2	68°F	58°F	63°F

[1]The minimum temperature shown is only the minimum recorded when the crew was in the field. Nighttime temperatures were certainly lower than those observed during the survey.
[2]The average temperature shown is not a true average temperature, as it only averages the grab samples recorded when the crew was in the field in Reach 3.

Water temperatures were recorded with grab samples throughout the stream survey process. Temperatures were recorded at every tenth riffle and pool. Only 2 samples (one pool, one riffle) were recorded in Reach 3. Temperatures were within the desirable temperature range for Rio Grande cutthroat trout of <64-68°F.

Habitat Characteristics

Reach 3 of Cow Creek was broken into 21 individual NSO's. Of these 21 NSO's, Reach 3 was composed of 7 pools, 7 riffles, 6 waterfalls, and 1 side channel. One of these waterfalls, a 20' high barrier (see Photo 11), is proposed as the potential lower range for RGCT habitat expansion. Although the pool to riffle ratio in the reach is 1:1, only 5.6 percent of the habitat in Reach 3 is pool habitat. Riffle habitat comprises 90.6% of the reach, over 16 times more than pool habitat. With far less than 30% of habitat in pools, Reach 3 is **not properly functioning** for pool development (see Table 25). However, this low percentage of pool habitat is most likely attributed to the large amount of bedrock within the reach (see Table 26) and maybe within the range of natural variability. Almost all pools within Reach 3 are just below a waterfall or chute, which provides the force necessary to scour out the bedrock substrate.

Table 25. Overall stream summary for Reach 3.

Reach 3					
Stream Length Surveyed: 0.78 miles (4066')			**Gradient**: 4.9%	**Rosgen Channel Type:** A1	
Habitat Type	**Number**	**Total Feet of Stream Habitat**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	7	238	5.8	5.6	>30%
Riffle	7	3828	94.1	90.6	-
Culvert	0	-	-	-	-
Tributary	0	-	-	-	-
Falls	6	97	0.1	2.4	-
Side Channel	1	60	-	1.4	-
Total	21	4223	100	100	-

Riffles in Reach 3 were consistent with a Rosgen type A1 channel type. Reach 3 of Cow Creek was found to be **properly functioning** for stream sediment, having far less than 20% fines in riffles. Bedrock was the dominant substrate type throughout riffles in Reach 3. The low amount of fines within riffles in Reach 3 is due to the high gradient of 4.9% in the area.

Table 26. Summary of habitat and substrate percentages for riffles in Reach 3.

Reach 3 Riffle Habitat Summary					
	# Riffles	Avg Length	Avg Width	Avg Depth	Avg Max Depth
Reach 3	7	547	14.3	1.2	2.3
Substrate Summary					
	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock
Reach 3	4.3	7.1	12.9	25.7	50.0
Properly Functioning Indicators	<20.0	-	-	-	-

Reach 3 was found to be **properly functioning** for pool quality, with the average residual depth of pools being 4.1 feet. Of the pools in Reach 3, all 7 had residual depths of 3' or greater. Bedrock was the dominant substrate type in pools in Reach 3, with sand ranked last at 4.3%. The low amount of sand is due to the high gradient of the area. Table 28 below summarizes pool habitat in Reach 3.

Table 27. Summary of habitat and substrate percentages for pools in Reach 3.

Reach 3 Pool Habitat Summary											
	# Pools	Avg Length	Avg Width	Avg Max Depth	Avg PTC	Avg Residual Depth	Pools per Mile	# Pools w/ Residual Depth ≥1'	Pools w/ Residual Depth ≥1' per Mile	# Pools w/ Max Depth ≥3'	Pools w/ Residual Depth ≥3' per mile
Reach 3	7	34	19.0	5.0	0.9	4.1	9.0	7	9.0	7	9.0
Properly Functioning Indicators	-	-	-	-	-	≥1'	-	-	-	-	-
Substrate Summary											
	% Sand		% Gravel		% Cobble		% Boulder		% Bedrock		
Reach 3	14.3		10.0		8.6		14.3		52.8		

Reach 3 was **not properly functioning** for large woody debris, having 5.1 pieces of LWD per mile (4 total in the reach). In order to be properly functioning, greater than 30 pieces of LWD per mile are required. The lack of LWD in Reach 3 is suspected to be due to a combination of past fire suppression and private land use practices. It is suspected that several pieces may have been washed out during flooding in 2000 and 2001. Reach 3 was subject to flooding during both years. A large amount of debris observed within the floodplain in Reach 2 shows evidence of the potential loss of materials within the bankfull channel in Reach 3.

Reach 3 had 8.6% of banks unstable within the reach. However, with a stream gradient exceeding 4% the bank stability numeric is not applicable in Reach 3.

The width to depth ratio in Reach 3 of 13:1 is slightly above the recommended <12 for Rosgen's type A channel, placing Reach 3 in the **not properly functioning** category for width:depth ratio. This could be surveyor error. In order to verify, this should be studied further.

Table 28. Habitat characteristics for Reach 3.

	Pool:Riffle Ratio	Bankfull Width:Depth Ratio	Pieces of LWD per Mile	Total Feet Unstable	% Banks Unstable
Reach 3	1:1	13:1	5.1	700	8.6[1]
Properly Functioning Indicators	-	<12:1	>30	-	-

[1] Reach 3 has a stream gradient greater than 4%, thus not applicable to the bank stability criteria.

Reach 3 is proposed as the lower limit for RGCT distribution. The recommended barrier in this reach should be examined to ensure its functionality, and other barriers downstream from the 20' waterfall should be examined for their utility as buffer barriers as well.

Reach 4: Valdez Bridge to Road 86 Crossing

Reach 4 begins on private land (T16N, R13E, Sec. 7 SW ¼) and progresses upstream 0.81 miles to the Road 86 bridge crossing, over a gradient of 1.4%. Reach 4 starts at 7880' and climbs upstream to 7940'. This reach is a Rosgen type C5 channel with sand, gravel, and cobble equally as the dominant substrates. Reach 4 of Cow Creek is entirely on private land. This reach was broken due to an increase in streambank vegetation and bank stability. Reach 4 was surveyed on July 22, 2001, by C. Robertson (observer) and A. Bullock (recorder).

Reach 4 is an open pasture on private land. Bank vegetative cover within the reach is low, resulting from private land management practices, namely grazing. Vegetation in the reach consisted of grasses and willows. Plant vigor within the reach was low, stemming from grazing impacts.

Photo 19. Downstream view of the upper end of Reach 4, as seen from Road 86 (Spring 2002). Note: grazing effects on riparian vegetation.

Water temperatures were recorded with grab samples throughout the stream survey process. Temperatures were recorded at every tenth riffle and pool. Reach 4 consisted entirely of 1 riffle, so only one temperature was recorded in the reach. The temperature recorded of 70°F is above the desirable temperature range for Rio Grande cutthroat trout of <64-68°F. Cow Creek is wide, shallow, and largely unshaded throughout the reach,

allowing sunlight to warm the stream. With only one measure, however, it is difficult to make any predictive statements regarding temperature in Reach 4. A thermograph could be placed at both ends of the private land to determine this area's influence on stream temperature.

Table 29.

Table 31. Summary of habitat and substrate percentages for riffles in Reach 4.

Reach 4 Riffle Habitat Summary					
	# Riffles	Avg Length	Avg Width	Avg Depth	Avg Max Depth
Reach 4	1	4228	10	0.6	1.6
Substrate Summary					
	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock
Reach 4	30	30	30	10	0
Properly Functioning Indicators	<20.0	-	-	-	-

With no pools throughout the entire reach, Reach 4 is obviously **not properly functioning** for pool development and quality (see Table 30). The lack of pools throughout Reaches 4 and 5 is rather disconcerting. The homogenous nature of Cow Creek in these reaches is due to past (and present) land use practices on private land. Reach 4 is grazed right up to the stream's edge, with little riparian vegetation throughout the area (see Photo 19).

Reach 4 was **not properly functioning** for large woody debris, being completely devoid of LWD. The lack of LWD in Reach 4 is due to private land use practices, and is closely tied to the lack of pools within the reach. Although past fire suppression efforts upstream in the watershed play a small role, land use is the primary culprit. Also tied to land use, bank stability in Reach 4 was **not properly functioning**, with 23.8% of banks being unstable within the reach. Reach 4 was **properly functioning** with a width-to-depth ratio of 17:1 associated with a type C channel (see Table 32).

Table 32. Habitat characteristics for Reach 4.

	Pool:Riffle Ratio	Bankfull Width:Depth Ratio	Pieces of LWD per Mile	Total Feet Unstable	% Banks Unstable
Reach 4	0:1	17:1	0	2015	23.8
Properly Functioning Indicators	-	12<30:1	>30	-	<10

The absence of pools, high percentage of unstable banks, lack of large woody debris, and large amount of fine sediment depostion within Reach 4 all seem to stem from private land management practices within the reach. As this Reach is outside of Forest Service control, discussion and recommendations regarding the landowners current management practices could be initiated. Even though we can't directly manage the area, perhaps some good advice to the current landowner would go a long way towards restoring this reach, such as grant and tax credit programs offered by USFWS and Natural Resource Conservation Service. Reach 4 is by far the least functioning reach surveyed in the 2001 stream inventory.

Reach 5: From Road 86 Crossing to Private Boundary (T17N, R12E, Sec. 36)

Reach 5 begins on private land (T16N, R12E, Sec.12 NE ¼) and progresses upstream 2.22 miles to dual private land boundary (T17N, R12E, Sec. 36 SW¼), over a gradient of 0.9%. Reach 5 starts at 7940' and climbs upstream to 8080'. This reach is a Rosgen type C5 channel with sand, gravel, and cobble as the dominant substrates. Reach 5 is entirely on private land. This reach was broken due to the upstream portion being inaccessible private property. Reach 5 was surveyed on July 25, 2001, by C. Robertson (observer) and A. Bullock (recorder).

Reach 5 consists of a fairly open valley on private land. The riparian community within the reach consists of grasses, rushes, sedges, and willow species.

Water temperatures were recorded with grab samples throughout the stream survey process. Temperatures were recorded at the first and last NSO of every day, and at every tenth riffle and pool. Table 35 summarizes the temperatures recorded in Reach 5. As Reach 5 consisted primarily of riffle habitat, a temperature was recorded at the beginning and end of the day within the same riffle. Temperatures were within the desirable temperature range for Rio Grande cutthroat trout of <64-68°F. Although similar in structure to Reach 4, which had a temperature of 70°F, Reach 5 has a much higher level of riparian vegetation providing shade for the stream.

Table 33. Water temperatures calculated from grab samples in Reach 5.

Reach	Number of Samples	Max Temp	Min Temp[1]	Avg Temp[2]
5	2	67°		

Table 34. Overall stream summary for Reach 5.

Reach 5					
Stream Length Surveyed: 2.22 miles (11747')		**Gradient**: 0.9%		**Rosgen Channel Type:** C5	
Habitat Type	**Number**	**Total Feet of Stream Habitat**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	0	-	-	0	>30%
Riffle	1	11,717	99.7	94.7	-
Culvert	1	30	0.3	0.2	-
Tributary	5	-	-	-	-
Falls	0	-	-	-	-
Side Channel	3	630	-	5.1	-
Total	9	12377	100	100	-

As in Reach 4, it would have been preferable to break the riffle in Reach 5 into several riffle NSOs, particularly where tributaries and side channels occurred. This would have given a more accurate picture of the reach by increasing the number of samples, reducing the amount of stream habitat that the observer had to keep in his memory, and reducing the potential errors involved in lumping such a large section of stream together. It is recommended that Reach 5 be surveyed again to get a better picture of Cow Creek in this area.

Table 35. Summary of habitat and substrate percentages for riffles in Reach 5.

Reach 5 Riffle Habitat Summary					
	# Riffles	**Avg Length**	**Avg Width**	**Avg Depth**	**Avg Max Depth**
Reach 5	1	11717	12	0.8	2.6
Substrate Summary					
	% Sand	**% Gravel**	**% Cobble**	**% Boulder**	**% Bedrock**
Reach 5	30	30	30	10	0
Properly Functioning Indicators	<20.0	-	-	-	-

Similar to Reach 4, with no pools throughout its length, Reach 5 is **not properly functioning** for pool development and quality (see Table 34). The lack of pools throughout Reaches 4 and 5 is rather disconcerting. The homogenous nature of Cow Creek in these reaches is due to past (and present) land use practices on private land. Although the impacts of current practices are not as bad on Reach 5 as Reach 4, past land use is still taking a toll on the stream habitat and diversity within the reach.

Table 36. Habitat characteristics for Reach 5.

	Pool:Riffle Ratio	**Bankfull Width:Depth Ratio**	**Pieces of LWD per Mile**	**Total Feet Unstable**	**% Banks Unstable**
Reach 5	0:1	15:1	2.3	0	0
Properly Functioning Indicators	-	12>30:1	>30	-	<10

Reach 5 was **not properly functioning** for large woody debris, having 2.3 pieces of LWD per mile (see Table 36). In order to be properly functioning, greater than 30 pieces

of LWD per mile are required. The lack of LWD in Reach 5 is due to a combination of past fire suppression, severe flooding since the Viveash Fire, and private land use practices. As stated previously, past fire suppression efforts have effectively removed disturbance necessary for LWD recruitment in Cow Creek. It is hoped that the disturbance produced by the Viveash fire will aid in LWD recruitment in the immediate future. In addition, any LWD that was in place had to withstand the violent flood conditions that followed the Viveash fire. Reaches 4 and 5 were exposed to extreme flood conditions during the summers of 2000 and 2001.

The width to depth ratio of 15:1 is **properly functioning** for Rosgen's type C channel. Bank stability in Reach 5 was **properly functioning**, with no unstable banks recorded within the reach. Bank stability is the most remarkable difference between Reaches 4 and 5. Although past land use practices in the two reaches seem to be identical, it is obvious that current practices in Reach 5 are such that banks are able to produce and retain riparian vegetation needed to stabilize banks and provide shade and sources of structure and food to the stream.

As in Reach 4, Reach 5 is entirely outside of Forest Service management. However, it is recommended that discussion be initiated with private landowners once trees damaged in the Viveash Fire have begun to settle into the stream, to stress the importance of woody debris to fisheries and stream vitality. Reach 5 is in far better condition than Reach 4, but the distinct lack of pool habitat and low LWD numbers within the reach are a definite concern.

Reach 6: Private Land (not surveyed) – Boundary (T17N, R12E, Sec. 36) to Cow Creek Campground

Reach 6 encompasses the small tract of private land in T17N, R12E, Secs. 35 and 36. Access to conduct the stream inventory in this private section was not granted. The approximate stream length in Reach 6 is 0.9 miles. The stream and landform in Reach 6 are very similar to that of Reach 5.

Reach 7: Cow Creek Campground to Martin Bridge

Reach 7 begins at Cow Creek Campground on Forest Service land (T17N, R12E, Sec. 35 NE ¼) and progresses upstream 1.78 miles to the Martin Ranch Bridge, over a gradient of 4.2%. Reach 7 starts at 8160' and climbs upstream to 8520'. This reach is a Rosgen type A4 channel with gravel as the dominant substrate. Reach 7 begins on Forest Service land and ends on private land on the Martin Ranch. This reach was broken due to decreases in stream gradient and valley confinement. Reach 7 was surveyed from July 26 to 28, 2001, by C. Robertson (observer) and A. Bullock (recorder).

Reach 7 lies in a moderately confined valley. Road 92 parallels Cow Creek throughout the reach. There is one (1) road crossing within the reach (bridge). The riparian community within the reach is composed of grasses, rushes, sedges, speckled alder, and conifers.

Water temperatures were recorded with grab samples throughout the stream survey process. Temperatures were recorded at the beginning and end of every day and at every tenth riffle and pool. Four samples were recorded in Reach 7 (see Table 37). Temperatures were within the desirable temperature range for Rio Grande cutthroat trout of <64-68°F.

Table 37. Water temperatures calculated from grab samples in Reach 7.

Reach	Number of Samples	Max Temp	Min Temp[1]	Avg Temp[2]
7	4	58.0°F	50.0°F	54.0°F

[1]The minimum temperature shown is the minimum recorded during survey hours.
[2]The average temperature shown is not a true average temperature, as it only averages the grab samples recorded when the crew was in the field in Reach 7.

Habitat Characteristics

Reach 7 of Cow Creek was broken into 18 individual NSO's. Of these 18 NSO's, Reach 7 was composed of 8 pools, 8 riffles, 1 tributary, and 1 side channel. Although the pool to riffle ratio in the reach is 1:1, only 3.0% of the habitat in Reach 7 is pool habitat. Riffle habitat comprises 95.0% of the reach, over 32 times more than pool habitat. With far less than 30% of habitat in pools, Reach 7 is clearly **not properly functioning** for pool development (see Table 89).

Table 38. Overall stream summary for Reach 7.

Reach 7					
Stream Length Surveyed: 1.78 miles (9420')			**Gradient**: 4.2%	**Rosgen Channel Type:** A4	
Habitat Type	**Number**	**Total Feet of Stream Habitat**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	8	284	3.0	3.0	>30%
Riffle	8	9136	97.0	95.0	-
Culvert	0	-	-	-	-
Tributary	1	-	-	-	-
Falls	0	-	-	-	-
Side Channel	1	200	-	2.0	-
Total	18	9620	100	100	-

Riffles in Reach 7 were consistent with a Rosgen type A4 channel type. Reach 7 of Cow Creek was found to be **not properly functioning** for stream sediment, having greater than 20% fines in riffles. Gravel was the dominant substrate type throughout riffles in Reach 7. Once again the large amount of fines within riffles in Reach 7 is largely due to sediment inputs from the effects of the Viveash Fire (see Table 39).

Table 39. Summary of habitat and substrate percentages for riffles in Reach 7.

Reach 7 Riffle Habitat Summary					
	# Riffles	**Avg Length**	**Avg Width**	**Avg Depth**	**Avg Max Depth**
Reach 7	9	1164.5	18.6	1.2	2.1
Substrate Summary					
	% Sand	**% Gravel**	**% Cobble**	**% Boulder**	**% Bedrock**
Reach 7	24.4	26.9	21.2	23.8	3.7
Properly Functioning Indicators	<20.0	-	-	-	-

Reach 7 was found to be **properly functioning** for pool quality, with the average residual depth of pools being 1.7 feet. Of the pools in Reach 7, six out of eight had residual depths of 3' or greater. Although the quality of pools in Reach 7 was sufficient, the quantity of pool habitat was very low with only 3.0% of habitat in pools as stated above. Sand and gravel were the dominant substrate type in pools in Reach 7 (see Table 40).

Table 40. Summary of habitat and substrate percentages for pools in Reach 7.

Reach 7 Pool Habitat Summary											
	# Pools	Avg Length	Avg Width	Avg Max Depth	Avg PTC	Avg Residual Depth	Pools per Mile	# Pools w/ Residual Depth ≥1'	Pools w/ Residual Depth ≥1' per Mile	# Pools w/ Max Depth ≥3'	Pools w/ Residual Depth ≥3' per mile
Reach 7	8	35.5	15.9	2.4	0.7	1.7	4.5	8	4.5	6	3.4
Properly Functioning Indicators	-	-	-	-	-	≥1'	-	-	-	-	-
Substrate Summary											
		% Sand		% Gravel		% Cobble		% Boulder		% Bedrock	
Reach 7		28.8		28.8		18.7		18.7		5.0	

Reach 7 was **not properly functioning** for large woody debris, with 3.9 pieces of LWD per mile (see Table 41). In order to be properly functioning, greater than 30 pieces of LWD per mile are required. The lack of LWD in Reach 7 is likely due to a combination of past fire suppression and severe flooding since the Viveash Fire. The slope and landform in Reach 7 are such that LWD would easily be washed downstream during flood flows. It is suspected that several pieces may have been washed out during flooding in 2000 and 2001.

The width to depth ratio of 16:1 in Reach 7 is **not properly functioning** for Rosgen's type A channel. In order to determine if this is surveyor error or if the stream is widening and shallowing, a more thorough survey should be conducted.

Reach 7 had 14.4% of banks unstable within the reach, exceeding the 10% standard for properly functioning. However, with a stream gradient of greater than 4%, the bank stability numeric is not applicable in Reach 7 (see Table 41), since often instability is due to natural conditions related to higher gradient systems.

Table 41. Habitat characteristics for Reach 7.

	Pool:Riffle Ratio	Bankfull Width:Depth Ratio	Pieces of LWD per Mile	Total Feet Unstable	% Banks Unstable
Reach 7	1:1	16:1	3.9	2720	14.4[1]
Properly Functioning Indicators	-	<12:1	>30	-	-

[1] Reach 7 has a stream gradient greater than 4%, thus the bank stability criteria is not applicable.

Road 92 closely parallels Cow Creek throughout the reach. During the high volume runoff events following the Viveash Fire, the road often washed out in places, and served as a source of sediment into Cow Creek. It is recommended that the possible continuing effects of the road as a source of sediment input be examined in greater detail. In addition, further analysis should be conducted to determine if road re-alignment is feasible to pull the road away from the stream and out of the floodplain.

Reach 8: Martin Bridge to Martin/SFNF Boundary

Reach 8 begins on private land at the Martin Ranch bridge (T17N, R12E, Sec. 25 NW ¼) and progresses upstream 3.02 miles to the boundary of the ranch and Forest Service land, over a gradient of 1.8%. Reach 8 starts at 8520' and climbs upstream to 8800'. This reach is a Rosgen type C5 channel with sand as the dominant substrate. Reach 8 is entirely on private land. This reach was broken due to increases in stream gradient and valley confinement. Reach 8 was surveyed from July 28 to Aug 21, 2001, by C. Luerkens (observer) and A. Bullock and C. Gatton (recorders).

Reach 8 consists of a very open valley. The Martin Ranch was untouched directly by the Viveash Fire. The riparian community in Reach 8 largely consists of grasses, rushes, sedges, speckled alder, and conifers. There are several meadow/pasture patches within the uplands, but for the most part the stream channel has a woody canopy cover throughout the reach.

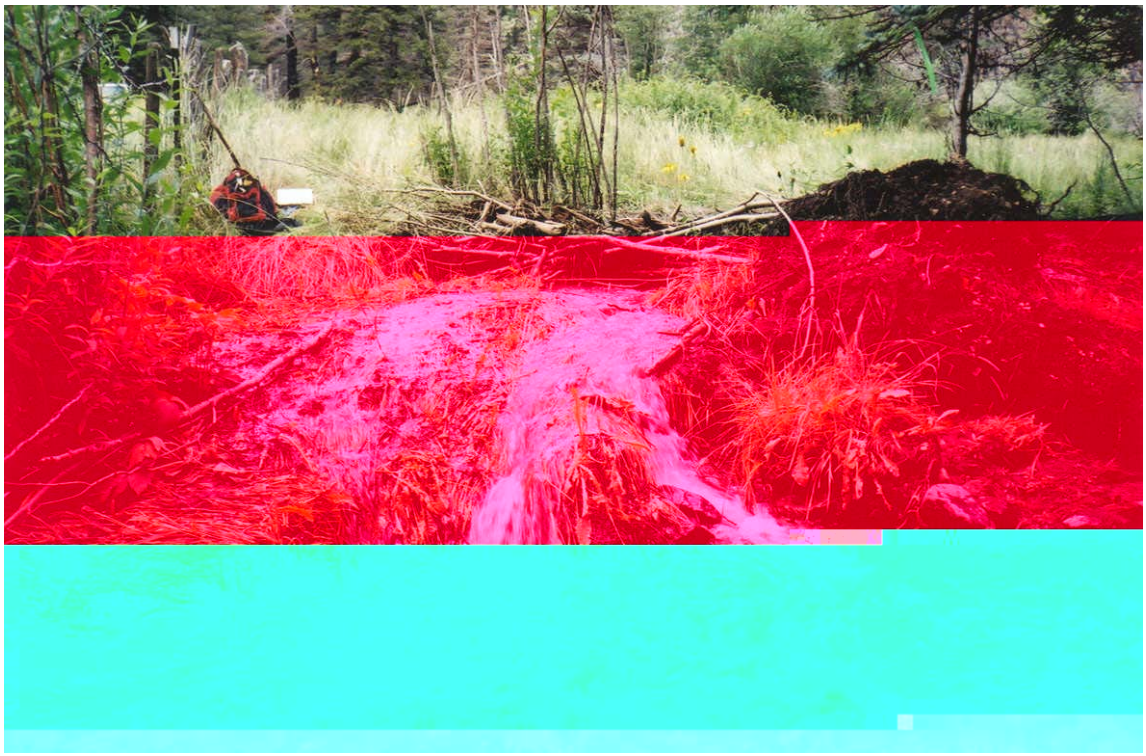


Photo 20. Reach 8, NSO132, T12. Tributary that has formed a new channel through grass (14 Aug 2001).

Water temperatures were recorded with grab samples throughout the stream survey process. Temperatures were recorded at the first and last NSO of every day, and at every tenth riffle and pool. Temperatures were within the desirable temperature range for Rio Grande cutthroat trout of <64-68°F.

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Table 42. Water temperatures calculated from grab samples in Reach 8.

Reach	Number of Samples	Max Temp	Min Temp[1]	Avg Temp[2]
8	6	57°F	50°F	54.2°F

[1]The minimum temperature shown is only the minimum recorded when the crew was in the field. Nighttime temperatures were certainly lower than those observed during the survey.
[2]The average temperature shown is not a true average temperature, as it only averages the grab samples recorded when the crew was in the field in Reach 8.

Habitat Characteristics

Reach 8 of Cow Creek was broken into 69 individual NSO's. Of these 69 NSO's, Reach 8 was composed of 25 pools, 31 riffles, 6 tributaries, and 7 side channels. Although the pool-to-riffle ratio in the reach is 1:1.2, only 4.8 percent of the habitat in Reach 8 is pool habitat. Riffle habitat comprises 89.2% of the reach, almost 19 times more than pool habitat. With far less than 30% of habitat in pools, Reach 8 is **not properly functioning** for pool development (see Table 43).

Table 43. Overall stream summary for Reach 8.

Reach 8					
Stream Length Surveyed: 3.02 miles (15,962')		**Gradient**: 1.8%		**Rosgen Channel Type:** C5	
Habitat Type	**Number**	**Total Feet of Stream Habitat**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	25	812	5.1	4.8	>30%
Riffle	31	15150	94.9	89.2	-
Culvert	0	-	-	-	-
Tributa2BT	0	15993	Tm	27	/P

residual depths of 1’ or greater. Only 2 of the pools present had residual depths of 3’ or greater. This is largely due to the amount of fine substrates settling into pools in Reach 8, effectively filling the pools with sand. The percentage of habitat remains very low with only 4.8% of habitat in pools as stated above. Sand was by far the dominant substrate type in pools in Reach 8.

Table 45. Summary of habitat and substrate percentages for pools in Reach 8.

Reach 8 Pool Habitat Summary											
	# Pools	Avg Length	Avg Width	Avg Max Depth	Avg PTC	Avg Residual Depth	Pools per Mile	# Pools w/ Residual Depth ≥1’	Pools w/ Residual Depth ≥1’ per Mile	# Pools w/ Max Depth ≥3’	Pools w/ Residual Depth ≥3’ per mile
Reach 8	25	32.5	11.0	2.4	0.8	1.6	8.3	25	8.3	2	0.7
Properly Functioning Indicators	-	-	-	-	-	≥1’	-	-	-	-	-

Substrate Summary					
	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock
Reach 8	59.6	10.4	24.4	5.6	0.0

Reach 8 was **not properly functioning** for large woody debris, having only 2.0 pieces of LWD per mile (see Table 46). In order to be properly functioning, greater than 30 pieces of LWD per mile are required. The lack of LWD in Reach 8 is largely due to a past and present land use practices. Cow Creek in Reach 8 follows a private road for a large portion of its length. During the stream inventory, timber was being harvested between the road and the stream in the lower half of Reach 8.

Table 46. Habitat characteristics for Reach 8.

	Pool:Riffle Ratio	Bankfull Width:Depth Ratio	Pieces of LWD per Mile	Total Feet Unstable	% Banks Unstable
Reach 8	1:1.2	13:1	2.0	1295	4.0
Properly Functioning Indicators	-	12>30:1	>30	-	<10

The width to depth ratio of 13:1 in Reach 8 is consistent with Rosgen’s type C channel. Bank stability in Reach 8 was **properly functioning**, with a mere 4.0% of banks being unstable within the reach.

As stated above, timber harvest was occurring between the road and the stream. While this is private land and beyond our management control, it is recommended that the land owners be made aware of the value of both standing trees and woody debris as stream resources.

Reach 9: Martin/SFNF Boundary to Elk Creek

Reach 9 begins on Forest Service land at the boundary of the Martin Ranch and the Santa Fe National Forest (T17N, R13E, Sec. 7 SW ¼) and progresses upstream 2.15 miles to the mouth of Elk Creek, over a gradient of 3.5%. Reach 9 starts at 8800' and climbs upstream to 9200'. This reach is a Rosgen type B4 channel with gravel as the dominant substrate. Reach 9 is mostly on Forest Service land, but does cross a section of private land. This reach was broken due to the amount of flow contributed by Elk Creek, and an increase in stream gradient. Reach 9 was surveyed from August 21 to23, 2001, by C. Luerkens (observer) and D. Lefthand (recorder).

Photo 21. Reach 9, NSO 198, P69. Typical cascade habitat (22 Aug 2001).

Reach 9 is in a moderately confined valley. As the reach nears the upper end at Elk Creek, confinement gradually increases. Woody vegetation in the upper end of the reach was severely burned in the Viveash Fire. The lower portion of the reach was largely untouched in the Viveash Fire. The riparian community within the reach consisted largely of grasses, rushes, sedges, speckled alder, and conifers.

Table 47. Water temperatures calculated from grab samples in Reach 9.

Reach	Number of Samples	Max Temp	Min Temp[1]	Avg Temp[2]
9	9	57°F	48°F	52.3°F

[1]The minimum temperature shown is only the minimum recorded when the crew was in the field. Nighttime temperatures were certainly lower than those observed during the survey.
[2]The average temperature shown is not a true average temperature, as it only averages the grab samples recorded when the crew was in the field in Reach 9.

Water temperatures were recorded with grab samples throughout the stream survey process. Temperatures were recorded at the first and last NSO of every day, and at every tenth riffle and pool. Nine samples were recorded. Temperatures were within the desirable temperature range for Rio Grande cutthroat trout of <64-68°F.

Habitat Characteristics

Table 48. Over

Reach 9 was found to be **properly functioning** for pool quality, with the average residual depth of pools being 1.4 feet. Of the 28 pools in Reach 9, 23 had residual depths of 1' or greater. Only 1 pool present had a residual depth of 3' or greater. As in Reach 8, this is largely due to the amount of fine substrates settling into pools in Reach 9, effectively filling the pools with sand. Sand was the dominant substrate in pools in Reach 9.

Table 50. Summary of habitat and substrate percentages for pools in Reach 9.

Reach 9 Pool Habitat Summary											
	# Pools	Avg Length	Avg Width	Avg Max Depth	Avg PTC	Avg Residual Depth	Pools per Mile	# Pools w/ Residual Depth ≥1'	Pools w/ Residual Depth ≥1' per Mile	# Pools w/ Max Depth ≥3'	Pools w/ Residual Depth ≥3' per mile
Reach 9	28	25.8	14.6	2.1	0.8	1.4	13.0	23	10.7	1	0.5
Properly Functioning Indicators	-	-	-	-	-	≥1'	-	-	-	-	-

Substrate Summary					
	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock
Reach 9	35.4	26.4	20.7	11.8	5.7

Reach 9 was **not properly functioning** for large woody debris, having only 9.3 pieces of LWD per mile (20 total in the reach). In order to be properly functioning, greater than 30 pieces of LWD per mile are required. Although low, LWD is dramatically higher than in previous reaches. Reach 9 is much more heavily forested than previous reaches, and should show a tremendous increase in LWD in coming seasons due to disturbance caused by the Viveash Fire.

Photo 22. Reach 9, NSO183, R75. Riffle with side channel. Note the amount of standing wood in the background (22 Aug 2001).

Table 51. Habitat characteristics for Reach 9.

	Pool:Riffle Ratio	Bankfull Width:Depth Ratio	Pieces of LWD per Mile	Total Feet Unstable	% Banks Unstable
Reach 9	1:1.1	15:1	9.3	897	4.0
Properly Functioning Indicators	-	12<30:1	>30	-	<10

The width-to-depth ratio of 15:1 is consistent with Rosgen's type B channel. Bank stability in Reach 9 was **properly functioning**, with 4.0% of banks being unstable within the reach.

With Reach 9 being in a more heavily forested area, and one that experienced severe burn intensity, it is recommended that this reach be observed to monitor the introduction of LWD into Cow Creek. Reaches 9 and 10 will potentially serve as strong sources of LWD, which should then be transported by Cow Creek to downstream reaches.

Reach 10: Elk Creek to Unnamed Tributary

Reach 10 begins at Elk Creek (T17N, R13E, Sec. 8 N ½) and progresses upstream 1.22 miles to an unnamed stream (T31) on the right bank, over a gradient of 6.2%. Reach 10 has the highest gradient of all reaches surveyed. Reach 10 starts at 9200' and climbs upstream to 9600'. This reach is a Rosgen type A4 channel with gravel as the dominant substrate. Reach 10 is entirely on Forest Service land. This reach was broken due to a reduction in stream flow. Reach 10 was surveyed from August 27 to 29, 2001, by C. Luerkens (observer) and D. Lefthand (recorder).

Reach 10 flows through a fairly well confined canyon, with many unique bedrock features. The majority of woody vegetation within the reach was killed during the Viveash Fire (see Photo 23), however a number of speckled alder root-sprouts were observed. Riparian herbaceous vegetation within the reach shows high vigor, and is composed of some desirable species (rushes and sedges) and grasses.

Photo 23. Reach 10, NSO239, F10. Chute just upstream from the mouth of Elk Creek. Note the fire-damaged trees in background (27 Aug 2001).

Water temperatures were recorded with grab samples throughout the stream survey process. Temperatures were recorded at the beginning and end of every day and at every tenth riffle and pool. Twelve samples were recorded in Reach 10. Temperatures were within the desirable temperature range for Rio Grande cutthroat trout of <64-68°F.

Table 52. Water temperatures calculated from grab samples in Reach 10.

Reach	Number of Samples	Max Temp	Min Temp[1]	Avg Temp[2]
10	12	56.0°F	49.0°F	52.7°F

[1] The minimum temperature shown is only the minimum recorded when the crew was in the field. Nighttime temperatures were certainly lower than those observed during the survey.
[2] The average temperature shown is not a true average temperature, as it only averages the grab samples recorded when the crew was in the field in Reach 10.

Habitat Characteristics

Table 53. Overall stream summary for Reach 10.

Reach 10					
Stream Length Surveyed: 1.22 miles (6406')			**Gradient**: 6.2%	**Rosgen Channel Type:** A4	
Habitat Type	**Number**	**Total Feet of Stream Habitat**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	18	289	4.5	4.4[1]	>30%
Riffle	20	6101	95.2	92.8	-
Culvert	0	-	-	-	-
Tributary	4	-	-	-	-

Although residual pool depth is barely above the minimum for properly functioning, this is more due to smaller stream size than to pools filling in with sediment. 11 out of 18 pools in Reach 10 had residual depths of 1' or greater. No pools with residual depths of 3' or greater were present. Gravel was the dominant substrate type in pools in Reach 10.

Table 55. Summary of habitat and substrate percentages for pools in Reach 10.

Reach 10 Pool Habitat Summary											
	# Pools	Avg Length	Avg Width	Avg Max Depth	Avg PTC	Avg Residual Depth	Pools per Mile	# Pools w/ Residual Depth ≥1'	Pools w/ Residual Depth ≥1' per Mile	# Pools w/ Max Depth ≥3'	Pools w/ Residual Depth ≥3' per mile
Reach 10	18	16.1	10.3	1.6	0.5	1.2	14.8	11	9.0	0	0.0
Properly Functioning Indicators	-	-	-	-	-	≥1'	-	-	-	-	-

Substrate Summary					
	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock
Reach 10	28.3	40.6	10.6	14.4	6.1

Reach 10 was **not properly functioning** for large woody debris, although the second highest number of LWD per mile is found within this reach at 12.3 pieces of LWD per mile (see Table 56). In order to be properly functioning, greater than 30 pieces of LWD per mile are required. As with Reach 9, LWD is expected to increase over the next few seasons as trees damaged during the Viveash Fire fall into the stream channel.

Table 56. Habitat characteristics for Reach 10.

	Pool:Riffle Ratio	Bankfull Width:Depth Ratio	Pieces of LWD per Mile	Total Feet Unstable	% Banks Unstable
Reach 10	1:1.1	13:1	12.3	89	0.7[1]
Properly Functioning Indicators	-	<12:1	>30	-	-

[1] Reach 10 has a stream gradient greater than 4%, exceeding the bank stability numeric.

The width-to-depth ratio of 13:1 is **not properly functioning** for Rosgen's type A channel. In order to be properly functioning, a type A channel should have a width to depth ratio of less than 12:1. This is possibly surveyor error. Further study should be conducted to verify.

Reach 10 had 0.7% of banks unstable within the reach, which is below the threshold for properly functioning. However, with a stream gradient of 6.2%, the bank stability numeric is not applicable in Reach 10.

It is recommended that Reach 10 be more thoroughly surveyed to determine the lower end of RGCT range. It is suspected that the lower boundary for RGCT is the large fall/chute complex found in the reach, but a more thorough fish survey is needed to confirm that speculation. A survey of the area was scheduled for September 2002, but poor weather conditions prevented snorkeling for the two days scheduled.

Reach 11: Unnamed Tributary to Headwaters

Reach 11 begins at an unnamed stream (T31) on the right bank (T18N, R13E, Sec. 32 SE ¼) and progresses upstream 4.0 miles to the headwaters of Cow Creek (T18N, R13E, Sec. 27 NE¼), over a gradient of 5.7%. Reach 11 starts at 9600' and climbs upstream to 10,800'. This reach is a Rosgen type A4 channel with gravel as the dominant substrate. Reach 11 is entirely on Forest Service land. This reach was broken at the spring-fed headwaters of Cow Creek. Reach 11 was surveyed from August 29 to September 10, 2001, by C. Luerkens (observer) and D. Lefthand and C. Gatton (recorders).

Reach 11 consists largely of an open meadow system. Banks within the reach were well covered by equisetum and grasses. Some conifers occur along streambanks as well. In the lower end of the reach, sporadic speckled alder were observed.

Photo 24. Reach 11, NSO310, R133. Meadow near the headwaters of Cow Creek. Note: Grass height. (30 Aug 2001).

Water temperatures were recorded with grab samples throughout the stream survey process. Temperatures were recorded at the beginning and end of every day and at every tenth riffle and pool. Seven samples were recorded in Reach 11. Temperatures were within the desirable temperature range for Rio Grande cutthroat trout of <64-68°F.

Table 57. Water temperatures calculated from grab samples in Reach 11.

Reach	Number of Samples	Max Temp	Min Temp[1]	Avg Temp[2]
11	7	54.0°F	44.0°F	49.6°F

[1]The minimum temperature shown is only the minimum recorded when the crew was in the field. Nighttime temperatures were certainly lower than those observed during the survey.
[2]The average temperature shown is not a true average temperature, as it only averages the grab samples recorded when the crew was in the field in Reach 11.

Habitat Characteristics

Reach 11 of Cow Creek was broken into 175 individual NSO's. Of these 175 NSO's, Reach 11 was composed of 69 pools, 81 riffles, 23 tributaries, 1 waterfall, and 1 side channel. Although there are 69 pools in Reach 11 with a pool to riffle ratio 1:1.2, only 3.5%of the habitat in Reach 11 is pool habitat. Riffle habitat comprises 96.5% of the reach, almost 28 times more than pool habitat. Reach 11 is excluded from the pool development numeric however, as Cow Creek is a 1st and 2nd order stream within the reach.

Table 58. Overall stream summary for Reach 11.

Reach 11					
Stream Length Surveyed: 4.00 miles (21,058')		**Gradient**: 5.7%		**Rosgen Channel Type:** A4	
Habitat Type	**Number**	**Total Feet of Stream Habitat**	**% Stream Length**	**% Stream Habitat**	**Properly Functioning Indicators**
Pool	69	733	3.5	3.5[1]	>30%
Riffle	81	20323	96.3	96.5	-
Culvert	0	-	-	-	-
Tributary	23	-	-	-	-
Falls	1	2	0.0	0.0	-
Side Channel	1	45	-	0.2	-
Total	162	21103	100	100	-

[1] In Reach 11 Cow Creek is a 1st to 2nd order stream, and is not applicable for the pool development criteria.

Riffles in Reach 11 were consistent with a Rosgen type A4 channel type. Reach 11 of Cow Creek was found to be **not properly functioning** for stream sediment, having greater than 20% fines in riffles (see Table 59). Gravel was the dominant substrate type throughout riffles in Reach 11.

Table 59. Summary of habitat and substrate percentages for riffles in Reach 11.

Reach 11 Riffle Habitat Summary					
	# Riffles	**Avg Length**	**Avg Width**	**Avg Depth**	**Avg Max Depth**
Reach 11	81	261.0	4.2	0.4	0.9
Substrate Summary					
	% Sand	**% Gravel**	**% Cobble**	**% Boulder**	**% Bedrock**
Reach 11	31.3	33.7	28.9	4.4	1.7
Properly Functioning Indicators	<20.0	-	-	-	-

Reach 11 was found to be **not properly functioning** for pool quality, with the average residual depth of pools falling just short at 0.9 feet (see Table 60). This is partially explained by the size of the stream in Reach 11. Pools in Cow Creek in Reach 11 are an average of 5.6 feet wide. Only 22 of the 69 pools in Reach 11 had residual depths of 1' or greater. No pools in Reach 11 had residual depths of 3' or greater. Although small stream size is a definite factor in pool quality, the large amount of fine sediment in the reach is also influencing pool depth. Fines (sand, silt, and clay) were the dominant substrate type in pools in Reach 11. Fine sediment levels within the reach were such that spawning habitat for salmonids is in extremely poor condition.

Table 60. Summary of habitat and substrate percentages for pools in Reach 11.

Reach 11 Pool Habitat Summary											
	# Pools	Avg Length	Avg Width	Avg Max Depth	Avg PTC	Avg Residual Depth	Pools per Mile	# Pools w/ Residual Depth ≥1'	Pools w/ Residual Depth ≥1' per Mile	# Pools w/ Max Depth ≥3'	Pools w/ Residual Depth ≥3' per mile
Reach 11	69	11.2	5.6	1.1	0.3	0.9	17.3	22	5.5	0	0.0
Properly Functioning Indicators	-	-	-	-	-	≥1'	-	-	-	-	-

Substrate Summary					
	% Sand	% Gravel	% Cobble	% Boulder	% Bedrock
Reach 11	45.2	29.1	20.3	4.5	0.9

Reach 11 had the highest amount of LWD per mile of any reach surveyed. However, at only 15.5 pieces per mile, it remains **not properly functioning** for large woody debris (see Table 61). In order to be properly functioning, greater than 30 pieces of LWD per mile are required. This low number can partially be attributed to the large meadow in the upper end of the reach. As with the previous reaches, LWD is expected to increase over the next few seasons as trees damaged during the Viveash Fire fall into the stream channel. The upper reaches of Cow Creek (reaches 9-11) will also act as transport reaches, with some LWD being carried downstream to settle out in reaches with a gentler gradient.

Table 61. Habitat characteristics for Reach 11.

	Pool:Riffle Ratio	Bankfull Width:Depth Ratio	Pieces of LWD per Mile	Total Feet Unstable	% Banks Unstable
Reach 11	1:1.1	12:1	15.5	270	0.9[1]
Properly Functioning Indicators	-	Type A <12	>30	-	-

[1] Reach 11 has a stream gradient greater than 4%, thus the bank stability criteria is not applicable.

The width-to-depth ratio of 12:1 is **properly functioning** for Rosgen's type A channel. Reach 11 had 0.9% of banks unstable within the reach, which is below the threshold for properly functioning. However, with a stream gradient of 5.7%, the bank stability numeric is not applicable in Reach 11.

In Reach 11, as in Reach 10, RGCT distribution needs to be more thoroughly examined. The upper limit of RGCT range needs to be determined and, if possible, what limiting factor (natural or otherwise) is keeping RGCT out of the upper end of the reach. In addition, cattle impacts on the stream channel need to be determined in greater detail.

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ACKNOWLEDGEMENTS

The Pecos/Las Vegas Ranger District fisheries program would like to thank the following people for their support: Sean Ferrell and Bill Britton for their leadership and guidance; Amy Unthank for reviewing the draft of this document; Julie True for her assistance with the GPS units, data dictionaries, and answering endless GIS questions; Dan Crittenden for his support while serving as District Ranger; Danny Roybal for supplying the photographs of the Viveash Fire; Kendall Brown for his assistance with range and fisheries information and his field contributions in fisheries; and everyone else on the Pecos Ranger District for their support and contributions.

Finally, thanks to the seasonal field crew personnel who conducted the ground work collecting data for this report: Anne Bolick (NMSU), Cody Robertson (NMSU), Chris Luerkens (WWU), and Dwayne Lefthand (NMHU).